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THE IMPACT OF THE PROTOTYPE OIL SHALE DEVELOPMENT ON
AGRICULTURAL AND MUNICIPAL WATER SUPPLIES IN
THE UINTAH BASIN

by

Roger Orson Tew

A thesis submitted in partial fulfillment of
the requirements for the degree

of

MASTER OF ARTS

in

Economics

Approved:

Utah State University
Logan, Utah

1976

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ABSTRACT

THE IMPACT OF THE PROTOTYPE OIL SHALE DEVELOPMENT ON
AGRICULTURAL AND MUNICIPAL WATER SUPPLIES IN
THE UINTAH BASIN

by

Roger Orson Tew, Master of Arts

Utah State University, 1976

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Department: Economics

In this paper the institutional factors affecting water distribution in the Upper Colorado River Basin in general and the Uintah Basin are presented. The historical development of the appropriation doctrine of water allocation is outlined and Utah water policy is examined. These institutional factors are analyzed in light of the prototype oil shale development in the Uintah Basin and potential impact on the area's agricultural sector. Oil shale water estimates are compared with Uintah Basin water availability and examined with regard to population projections and municipal water use. Lastly, Utah water policy and the appropriation doctrine are viewed as restraints to efficient water transfers.

(94 pages)

INTRODUCTION

It has often been alleged that the development of the arid western United States has been limited by the lack of water. The amount of that resource available has dictated agricultural production and the location of settlements.

Recent years have witnessed large price increases in energy, and the nation is searching for new forms that are economically feasible and environmentally acceptable. As a result, much attention is being focused on the development of alternatives to liquid petroleum.

Oil shale is one of the most abundant but undeveloped forms of energy in the United States. High grade deposits, located within the Green River formation of Utah, Colorado, and Wyoming (Upper Colorado River Basin), contain the equivalent of 600 billion barrels of oil. Exploitation of this resource would offer a significant supplement to U.S. supplies of liquid petroleum. Studies of the feasibility of oil shale indicate that the availability of large quantities of water will play a key role in determining to what extent an oil shale industry can become a reality.

It is apparent that the legal right to utilize water will be perhaps the most important factor in the consideration of water for energy in the Upper Colorado River Basin. From available data it is obvious that present water availability exceeds that which is presently utilized in the Basin. However, it is also apparent that this quantity of water is in turn exceeded by present rights granted by

most states in the area. The obvious conclusion is that many appropriate rights granted to private parties are not being fully utilized. Nonetheless, these rights remain as charges against the future availability of water in the oil shale rich areas. How state water control agencies reconcile current water administration policies with the need for energy water will determine to a large extent if oil shale operations will become a reality.

Since the bulk of existing water rights in the Upper Colorado River Basin are associated with agriculture, there has been some concern that increased energy water demands will have a detrimental impact on the area's agriculture. In attempting to assess the impact of oil shale development upon existing agricultural water supplies, this thesis will focus upon three principal areas of investigation:

1. To examine the current Utah water policies, laws, regulations, as well as other factors which are affecting the development of the state's water resources. Much of the legislation governing water use and development in Utah also incorporates aspects of broader, regional policies, such as Colorado River Compact and the Upper Colorado River Compact. Therefore, water policies will be investigated from a multi-state or regional viewpoint as well as from the vantage point of Utah's own water policies. Primary emphasis will be placed upon the legislation and problems dealing with the Upper Colorado River Basin.

2. To examine the oil shale development firms, the mining and retorting processes, and the associated water requirements. Likely alternatives for obtaining water for oil shale will also be studied.

3. To evaluate the impact of oil shale development on agriculture. The geographic area of study will be the Uintah Basin in general and the Ashley Valley-Vernal City area specifically. We will examine population impacts in the Uintah Basin, water sources for the Basin and Ashley Valley, and the restraints which exist regarding oil shale's use of agricultural water.

The study presumes that oil shale development will reach only the prototype stage of development in the near future. This represents a capacity of approximately 100,000 barrels/day.

FACTORS AFFECTING CURRENT STATE WATER POLICY

The very nature of the prior appropriation doctrine is one of extensive institutional involvement in the allocation of water. The scarcity of water throughout the west has prompted the enactment of several major interstate and international compacts.

Nowhere is this situation more apparent than with the Colorado River, quite possibly the most regulated waterway in the world. The legislation, compacts, treaties, and other agreements which govern the Colorado River system are known collectively as the "Law of the River." (See map Upper Colorado River Basin)

It is obvious, therefore, that allocation of Utah's water resources will be done within this institutional framework. Energy development will have to compete with other demands for the state's valuable water resources.

The purpose of this section is to explore the regulations of the Colorado River system, explain the appropriate doctrine as it relates to the State of Utah, identify the competing demands for water within the state, and present the current factors and proposals affecting the development of a state-wide water policy.

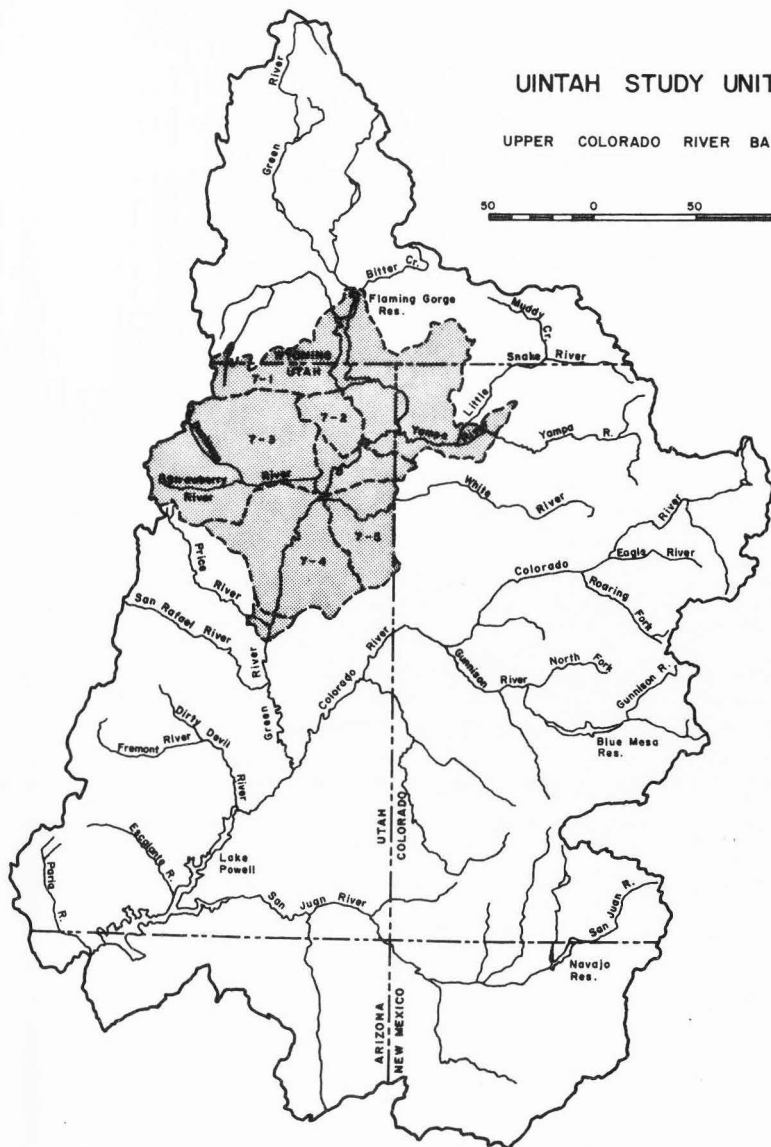
The Colorado River System

The cornerstone of the body of law regulating the Colorado River is the Colorado River Compact of 1922. The parties involved are the federal government, the states of Utah, Colorado, Arizona, New Mexico, Wyoming, Nevada, and California. The primary purpose of the compact is to distribute the United States entitlement of flow of the river

UINTAH STUDY UNIT

UPPER COLORADO RIVER BASIN

50 0 50 100 Miles



equally between the upper basin states (Utah, Colorado, Wyoming, and New Mexico) and the lower basin states (Arizona, California, and New Mexico). Based upon pre-1920 data, the compact established the total flow of the river available for distribution among the upper and lower basin states at 15 million acre feet (m.a.f.). The major provision of the compact is one requiring the upper basin states to deliver a minimum of 75 m.a.f. to the lower basin states in any consecutive 10-year period. The Mexican Water Treaty of 1944 guarantees Mexico an annual quantity of 1,500,000 a.f. of water from any and all sources.¹

While the 1922 compact regulates the river as to the allotment between the upper and lower basins, it does not divide the water between the individual states of each area. The Upper Basin Compact of 1948² allocates the water to the four participating states of the upper basin on a percentage basis in the following manner:³

| | |
|------------|--------|
| Colorado | 51.7% |
| Utah | 23.0% |
| New Mexico | 11.25% |
| Wyoming | 14.0% |

(Note: Arizona is guaranteed an annual flow of 50,000 a.f. from the upper basin allotment.)

A major problem with the original Colorado River Compact and the subsequent Upper Basin Compact is that information upon which

¹Report on Water for Energy in the Upper Colorado River Basin, U.S. Department of Interior; Water Management Team, July 1974, p. 2.

²Ibid.

³Ibid., p. 3.

the initial river flow was calculated was greatly overestimated and the later Mexican Treaty obligations had not been defined. Later years have shown that the river's total flow at Lee's Ferry is closer to 13.3 m.a.f. than the original estimate of 15 m.a.f.⁴ Therefore, the upper basin's entitlement is approximately 5.8 m.a.f. after fulfilling the lower basin's flow requirements, which are still held at 75 m.a.f. in any given 10-year period.⁵ However, it is the variability of the flow which has required the upper basin states to develop considerable storage capacity in order to reduce the effect of variability. (This was the motivating force behind the Colorado River Storage Project which included Glen Canyon Dam and Flaming Gorge Dam.)

Based upon the more accurate estimate of the total river flow,⁶ the percentage division of the upper basin's allotment entitles the four states to the following amounts of water:

| | |
|------------|----------------|
| Colorado | 2,976,000 a.f. |
| Utah | 1,322,000 a.f. |
| Wyoming | 805,000 a.f. |
| New Mexico | 627,000 a.f. |

It should be noted, however, that the above data are based upon Bureau of Reclamation estimates. The State of Utah generally takes a more liberal view with regards to its entitlement, and places the figure around 1.4 m.a.f. It is that estimate which will be utilized in this study. Also, the Colorado River proper does not flow through

⁴Ibid., p. 4.

⁵Ibid.

⁶Harl M. Noble, "Water Available for Oil Shale Development in the Upper Colorado River Basin and Related Water Quality Aspects." U.S. Geological Survey, March 7, 1974, p. 3.

Utah for any great distance. Nonetheless, 15% of the virgin flow of the river at Lee's Ferry does originate in Utah.⁷

Before outlining Utah's current and projected uses of the state's Colorado River allotment, mention should be made of the appropriative doctrine, which underpins all water-related development, and the statutory manner in which water rights are obtained.

Historical

The early water users in the west were generally miners and farmers who often trespassed upon the public domain to divert water from streams to the point of use. Because of the lack of courts and established local procedure regarding the use of water, these early inhabitants developed their own local customs. They were usually related to the same rules which governed mining districts and claims.

When water-use conflicts did reach the courts, the decisions tended to reflect these local characteristics rather than the traditional riparian views. The development of the west was dependent upon successful farming and mining and these activities were dependent upon water. Therefore, the courts and the Congress, recognizing the importance of such development, allowed water to be withdrawn by anyone who could put it to a beneficial use in accordance with the laws and customs of the respective states. Thus the law of prior appropriation was born.

The essentials of the concept are that water rights are acquired through the diverting of water from a natural watercourse and applying

⁷Daniel F. Lawrence and Barry C. Saunders, "Allocations of Utah's Colorado River Water," Irrigation and Drainage in an Age of Competition for Resources, American Society of Civil Engineers, August 1975, p. 82.

it to a beneficial use. This water right has a priority date which reflects the date that action was first taken to utilize the water. This priority establishes a relationship between a particular water right and all other water users on the stream. Those rights superior (earlier) are guaranteed their water supply before the needs of those inferior (later) can be met.

The appropriation doctrine in Utah developed in slightly different fashion than those areas where water rules were related to mining claims. The Mormon pioneers were the first Anglo-Saxons to practice irrigation on an extensive scale in the United States. Their colonization patterns involved the establishment of many small communities generally separated from each other by miles of desert and mountains and as a result were largely self-contained. The development of a cooperative-type irrigation system under Church control was usually one of the first activities of any new settlement.

The Mormon Church contemplated the colonization of the Great Basin in such a way as to maximize the use of the area's scarce water resources. This use would be applied to all land that could be reached by the water, not just those areas contiguous to the surface water channels.

The Church took possession of the region and supervised the allotments of parcels of land to settlers. These early rights were recognized by the Mormon State of Deseret and the Territory of Utah pending issuance of formal land titles by the United States. It was also established that those who had first made beneficial use of water should be entitled to continued use in preference to those who came

later. This fundamental principle was to be later sanctioned by the legislature and the courts.⁸

These early methods were terminated with statehood when the legislature provided that an appropriation could only be obtained through filing an application with the State Engineer. (Note: Those who owned rights prior to 1903 but had not yet perfected those rights in terms of putting the water to beneficial use were given a reasonable amount of time to do so. Of course, those who had claim to water based upon pre-1903 action still held title to the water.)

This 1903 statute was revised and reenacted in 1905 and again in 1919. The 1919 law is the basis of the present enactment contained in the Utah Code Annotated (1953).

The Utah appropriation statute contains the following declaration: "All waters in this state, whether above or under the ground are hereby declared to be the property of the public, subject to all existing rights to the use thereof." (73-1-1) "Rights to the use of the unappropriated public waters in this state may be acquired only as provided in this title." (73-3-1)⁹

The current laws, therefore, declare that the state has the right to control the diversion and distribution of the public waters within its boundaries. The control of the diversion and distribution of such public waters are vested in the State Engineer, subject to judicial review and to the constitutional provision recognizing

⁸A Summary Digest of State Water Laws, edited by Richard L. Dewsnap and Dallin Jensen, National Water Commission, 1973, p. 722.

⁹Wells A. Hutchins, The Utah Law of Water Rights, State Engineer of Utah and the U.S. Department of Agriculture, Salt Lake City, Utah, October 1965, pp. 17,18.

and confirming existing rights to the use of waters for useful and beneficial purposes.¹⁰ The statutes clearly make it the duty of the state to appropriate the water in a manner that will be in the best interests of the public.

This statutory procedure is now the exclusive method of appropriating water. Applications to appropriate are filed in the office of the State Engineer, and unappropriated water may be acquired for any recognized beneficial use. Subject to compliance with the statutory procedure for perfecting a water right, an application has priority as of the date it was filed in the State Engineer's office.¹¹

The laws state that it is the duty of the State Engineer to approve an application that meets the filing requirements if: (a) there is unappropriated water in the proposed source; (b) the proposed use will not impair existing rights or interfere with more beneficial use of the waters; (c) the proposed plan is physically and economically feasible and not detrimental to the public welfare; and (d) the applicant has the financial ability to complete the proposed works and has applied for the appropriation in good faith and not for speculation or monopoly. However, if the State Engineer has reason to believe that more beneficial use of the water for irrigation, domestic, stockwatering, power, mining, or manufacturing purposes will be interfered with or the public welfare will be adversely affected, he must withhold approval or rejection pending an investigation. (73-3-8)¹²

¹⁰ A Summary Digest of State Water Laws, edited by Richard L. Dewsnup and Dallin W. Jensen, National Water Commission, 1973, p. 722.

¹¹ Ibid.

¹² Hutchins, Utah Law of Water Rights, pp. 31, 32.

Once an application is approved, the applicant is given a specific time in which to place the water to beneficial use and submit written proof of appropriation. An applicant may be granted additional time for completing construction of the works and applying the water to beneficial use upon a showing of diligence or reasonable cause for delay.¹³ If an application lapses for failure of the applicant to comply with the provisions of the act, the State Engineer may, upon showing of reasonable cause, reinstate the application. However, the priority date of the application must be altered to reflect the date of reinstatement.¹⁴

Once the water is placed to beneficial use, the applicant submits proof of his actions and is issued a certificate of appropriation, which is filed in the State Engineer's office. Domestic purposes, stockwater, irrigation, municipal power, manufacturing, fish culture, and the use of navigable water for the recovery of salt and the minerals have all been classified as beneficial use of state waters.

A certificate of appropriation constitutes prima facie evidence of the water right. The right consists not only in the amount of the appropriation but also in the priority. It also extends to quality as well as quantity. A water right is considered as a species of real property and is protected as such. It is a usufructuary right, meaning the right to divert from the source of supply. Lastly, a water right in Utah is separate and distinct from the land upon

¹³The Utah Code Annotated (1953)., Sec. 73-3-12.

¹⁴The Utah Code Annotated (1953)., Sec. 73-3-18.

which it is used. However, if a deed transferring land does not specify otherwise, the water right passes with title to the land.¹⁵

Current Water Uses

Utilizing the administrative mechanism just outlined, Utah is currently depleting the Colorado River by 825,000 a.f. annually.¹⁶ Approximately 90 percent of the current diversions are related to agriculture, with 5 percent for municipal and industrial purposes, and 5 percent for managed wetlands.¹⁷ Of the municipal and industrial uses, about 7,800 a.f. are utilized in the production of thermal power.¹⁸

Although it would appear that nearly 600,000 a.f. are still available for the state to allocate, the current situation is one of strong competition for the remaining water. The following pages will discuss the problems facing Utah in allocating the state's remaining Colorado River allotment among the most likely water users.

Over-Appropriation

A common statement made regarding the Colorado River is that it is over-appropriated. As was previously mentioned, Utah currently utilizes 825,000 a.f. of the state's entitlement, leaving some 600,000 a.f. available. According to state officials this amount

¹⁵The Utah Code Annotated (1953) ., Sec. 73-1-11.

¹⁶D.C. Hansen, "Water for Energy and Agriculture," Irrigation and Drainage in an Age of Competition for Resources, American Society of Civil Engineers, Proceedings of a specialty conference conducted by the Irrigation and Drainage Division of the American Society of Civil Engineers, Logan, Utah, August 13-15, 1975, p. 67.

¹⁷Ibid.

¹⁸Ibid.

is sufficient to meet the foreseeable domestic demand of the state.¹⁹ Problems arise, however, if additional quantities will be demanded for agriculture and energy development.

The State Engineer has approved filings totaling just under 600,000 a.f. from the remaining amount of the state's allotment. These filings, if proved, could by themselves exhaust the entire entitlement.²⁰ The majority of this remaining water is covered by an approved application, in the name of the Bureau of Reclamation, for the Central Utah Project. That flow which remains is associated with approved applications in the lower reaches of the basin and along major tributaries of the Colorado River.

It is obvious, therefore, that Utah is currently utilizing or has commitments for using the entire 1.4 m.a.f. to which the state is entitled.

Indian Water Rights

The Supreme Court, in 1908, held that when Indian reservations were established, sufficient water to supply all Indian lands was also reserved. The Winters Doctrine interpretation discussed below, has made the Indians an important element in any plans to develop Utah's remaining water.

The case of Winters vs. United States is generally thought to be the real beginning of the reservation doctrine, an item which will be discussed at greater length later in this section. The essential point of the Winters decision is that waters set aside as belonging to the

¹⁹Ibid., p. 86.

²⁰Hansen, "Water for Energy and Agriculture," p. 69.

Indian reservations are superior to other subsequent appropriators who obtained their rights under state law, even though the Indians had not yet placed their waters to a beneficial use.²¹ The justification for the Winters decision is not clear. Some viewpoints, however, reflect the idea that the motive behind the action was to provide the Indians with the potential of rebuilding their lives after the westward migration had destroyed their previous livelihood.²²

One major problem with rights as defined under the Winters Doctrine is quantifying those rights. If all the land belonging to the Indians were to be assessed as arable, the water requirements would more than exhaust the remaining Colorado River allotment in Utah. Furthermore, negotiations with Indian representatives have seen these water demands continually reevaluated upward.

A second problem area is a legal one; whether the Winters Doctrine intended the reserved water to be utilized for other than agricultural related purposes. There has been no definitive answer to the question by the courts as yet and so the issue will remain moot until resolved.

The Indians have been involved in most recent water developments in the Colorado River Basin. Specifically, they have been guaranteed water in the new Central Utah Project (CUP). In 1965, a contract was executed between the United States (Bureau of Reclamation and Bureau of Indian Affairs), the Ute Indian Tribe, and the Central Utah Water Conservancy District, in which the non-Indian parties recognized 36,450 acres of Indian lands as being served or to be

²¹Ibid., p. 71.

²²Ibid.

served from the Duchesne River. For their part, the Indians agreed to defer development of 15,242 acres of non-irrigated land.²³ This particular agreement related only to the Bonneville Unit of the CUP, however. Similar deferrals should be executed for the Upalco and Uintah Units of the CUP totaling 13,876 acres.²⁴ Thus, the Ute Indians would defer irrigation to a total of 29,118 acres of land.²⁵

The key point in these actions is that the water use has been deferred, not abandoned. The agreement provides that Indian water supplies may be converted to uses other than agricultural, with the understanding that the total water to be used by the Indians will not exceed the equivalent of 4.0 acre-feet per acre for the acreage from which the water is converted.²⁶

Since the execution of these agreements there have been considerable delays in the full development of the Central Utah Project. Congress has failed to appropriate funds and inflation has forced alterations in original plans. These delays have lead to a general dissatisfaction by the Indians with the proposed development of their water rights, resulting in suits being filed to halt construction of the CUP until the Indian rights are guaranteed.

At the present time 129,201 acres of Ute and Ouray Reservation land are claimed and determined to be arable under the Winters Doctrine. If a water requirement of 3 acre-feet per acre is assumed,

²³Final Environmental Statement for the Bonneville Unit, Central Utah Project, Bureau of Reclamation; Department of the Interior, August 2, 1973, p. 24.

²⁴Ibid.

²⁵Ibid.

²⁶Ibid., p. 25.

the Ute tribe's rights to undeveloped Upper Colorado River Basin water would be 387,000 a.f. per year.²⁷ Thus, the Indians will be a major component in any future plans to develop the state's remaining water.

Salinity

Salinity problems arise because all water developments produce increases in salinity concentration. Public law 92-500 (Federal Pollution Act Amendments of 1972) implies that salinity levels should be maintained at or below 1972 levels.²⁸ There are essentially two ways of preventing salt buildup: take out the salt, or restrict further water use. Desalination is costly, and restricting further water use would essentially mean a moratorium on any development. Extensive work is being done on the salinity problem of the Colorado River. Nonetheless, any development on the river cannot proceed without consideration of the salt problem.

Federal Water Rights--The Reservation Doctrine

The reservation doctrine is based on the premise that since all of the land now occupied by the western states once belonged to the federal government, the western states did not acquire title to the public lands once they were admitted to the union. Therefore, the federal government still retains ownership of these federally-retained lands. These claims extend to the right to dispose of and regulate the public lands and waters in accordance with the Property Clause of the Constitution.²⁹

²⁷W. Chris Lewis, Socio-Economic Impact Study of Oil Shale Development in the Uintah Basin, Western Environmental Associates, 1975, Logan, Utah, p. 40.

²⁸Lawrence, "Allocation of Utah's Colorado River Water," p. 86.

²⁹Hansen, "Water for Energy and Agriculture," p. 70.

In answer to those who claim that the federal government relinquished control of these water rights with the Act of 1866, 1870, and the Desert Land Act of 1877, the federal government claims that control was only deferred to the western states, but ownership remained in the hands of the federal government.³⁰ Therefore, when the government reserved a part of the public domain for its own purposes, it also reserved sufficient water to facilitate these purposes.

The beginning of the reservation doctrine is generally associated with the Winters Doctrine, mentioned earlier in conjunction with Indian rights. However, subsequent cases indicate that the reservation doctrine may also apply to other water withdrawals.

The key problem with water rights claimed under the reservation doctrine is again one of no clearly defined amounts or purposes. The possibility of conflict between states and the federal government is always present since the watershed on which most of the streams and rivers originate in Utah and the other western states is federal land.

Efforts have been made in Congress to quantify the amount of water which would be classified as belonging to the federal government under the reservation doctrine. Until such time as the law is clarified there will always exist the possibility that presently allocated water would be subject to potential federal demands.

Potential Water Uses--Agriculture

The portion of the Upper Colorado River Basin located in Utah contains over one million acres of arable land.³¹ The 1965 Upper Colorado

³⁰ Ibid.

³¹ Lawrence, "Allocation of Utah's Colorado River Water," p. 88.

Region Framework Study sponsored by the Water Resources Council indicated that 307,600 acres were under irrigation.³² Of this portion 125,000 acres did not receive full irrigation requirements. (A full amount is defined by the study as water sufficient to satisfy consumptive use as calculated by the Elaney-Criddle method.)³³

The majority of the area's agricultural water rights are located along the Duchesne River in the Uintah Basin. Beef, grade A dairying, and sheep are the main enterprises. The principal crops are related to the livestock industry, and in order of greatest acreage are alfalfa, pasture, barley, corn silage, wheat, and oats. Livestock grazing is permitted on National Forest lands and the grazing districts of the Bureau of Land Management. The growing season is too short for most cash crops and precipitation is inadequate for dry farming.³⁴

Until very recently it appeared that agriculture would be the only major water user in the Colorado River system in Utah. To utilize the state's full allotment vast exports of water to the Bonneville Basin were contemplated. Potential new water uses, especially those related to energy, have permanently altered that view.

It is the view in the State Engineer's office that there are only two possibilities open to agriculture, since it is the use which will find it most difficult competing on the open market for sufficient water. First, the possibility exists that increases in demand for agricultural products will cause food prices to rise giving farmers

³²Ibid.

³³Ibid.

³⁴Gaylord V. Skogerboe and Lloyd Austin, Hydrologic Inventory of the Uintah Basin, Utah Water Resources, 1967, p. 33.

sufficient incentive and purchasing power to compete with other demands for water on the open market. Second, a public desire to preserve agriculture could prompt action by the state legislature, to prevent the transfer of water from agriculture to other uses.³⁵ Such an action would maintain the agricultural base and would essentially prohibit agricultural water rights from being allocated in the free market.

At the present time agricultural producers seem to be ambivalent about such an action. Many are concerned that water will not continue to be available for agricultural production. At the same time, however, farmers also see the possibility of selling their water rights at a high price to some industrial operation and using the income for retirement or for investment in some other business. Consequently they do not wish to see public action which would preclude this possibility.

Although new inbasin irrigation could conceivably consume vast amounts of water, committed agricultural water, which in this case means the Bonneville, Uintah, Upalco, and Jensen units of the Central Utah Project, will provide only about 108,000 a.f. for agriculture.³⁶

Energy

Energy related water uses are generally associated with four principal activities: oil shale, thermal-electric power generation, conventional coal mining, and coal gasification and liquefaction. Because of the nature of the energy shortage and the slow development of solar and nuclear power plants, the use of coal and other fossil fuels is approaching a crash status. In light of this situation the coal and oil shale reserves of Eastern Utah are of particular importance.

³⁵Hansen, "Water for Energy and Agriculture," p. 69.

³⁶Lawrence, "Allocation of Utah's Colorado River Water," p. 88.

The water requirements for coal mining are small, and often sufficient water is developed in the mine itself to meet mining needs. Electric generating plants consume about 15,000 a.f. of water annually per 1,000 megawatts of capacity.³⁷ The majority of the water is used for cooling purposes. At the moment only about 7,800 a.f. annually are being used for thermal power generation, but at least four large thermal plants are in various stages of development. The associated water requirements would be about 120,000 a.f. annually to supply an additional 8,000 megawatts of capacity.³⁸

The water requirements, methods of delivery, and uses of water for oil shale will be discussed in depth in a later chapter. Basically, the projected water needs for a 100,000 bls/day operation and a support community of 8,000 people are estimated at 36,000 a.f. annually.³⁹

Water for coal gasification and liquefaction is estimated at 15,000 a.f. per year for a 250 M cu. ft./day operation.⁴⁰ At the moment the number of plants and their size is speculative, although the amount of the state's coal deposits indicates that the industry will be important to Utah's energy development plans.

A problem, however, with all such experimental operations is that no large commercial plants have been attempted and the water estimates may be subject to considerable error.

³⁷Ibid.

³⁸Ibid.

³⁹Ibid.

⁴⁰Report on Water for Energy in the Upper Colorado River Basin.
U.S. Department of the Interior, Water Management Team, July 1974,
p. 38.

Wildlife and Recreation

Beside the water demands for agriculture, energy, and industry, there is considerable pressure to maintain streamflows for fishery, recreational, and aesthetic purposes. Some federal legislation including the Wilderness Act, Wild Horse and Burro Act and recently the Endangered Species Act, if interpreted literally, could stop all development for any purposes along many energy-related waterways. Section 7 of the Endangered Species Act reads, speaking of federal involvement in any way, "...the actions shall not jeopardize the continued existence of such endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with the affected States, to be critical."⁴¹ As an example of the potential implications of these environmental statutes, Utah and Colorado's oil shale tracts may be inhabited by five endangered species of mammals and fish. The federal involvement in the management of these tracts in leasing and developing them could eliminate any action which would alter in any way the natural habitat of these species. In effect, the action would eliminate development.

Environmental agitation for the preservation of the natural environment of Upper Colorado River Basin has had considerable impact. Recent political developments in the State of Colorado, for example, have delayed some energy development projects in that state. Finally there are some proposals to designate many of the energy-related

⁴¹John E. Phelps, "People, Water Resources, and Wildlife," Irrigation and Drainage in an Age of Competition for Resources, American Society of Civil Engineers, August 1975, p. 76.

waterways in Utah as wilderness areas. Such action would completely eliminate development along those rivers.

Future Water Policy

It should be obvious from the preceding pages, that the formulation of a state water policy which reflects current water needs is of paramount importance. Historically, the state, as represented by the Board of Water Resources and the State Engineer, has supported and encouraged any water development which did not injure other water users. The guiding principle was first in filing, first in right. This policy, however, has resulted in the potential overallocation of virtually all of Utah's streams and rivers. The problem is particularly acute in the Upper Colorado River Basin. It is now apparent that the problem is no longer one of getting the water developed, but of choosing between competing and often conflicting uses.

The administrative problems in dealing with the vast number of competing and conflicting water filings have resulted in the Governor formally declaring a moratorium on all water allocations in the state. In reality such a situation has existed for some time, especially in regards to the state's Colorado River water. As an example of the magnitude of the problem, energy filings totaling 1.2 m.a.f. are on file for the Upper Colorado River Basin alone.⁴² This amount is nearly equal to the state's entire Colorado River allotment.

The job of developing a comprehensive water policy will most likely incorporate two primary concepts: attempting to obtain maximum usage of presently approved water rights and formulating a sound criteria

⁴²Hansen, "Water for Energy and Agriculture," p. 68.

for the allocation of presently non-allocated water. In both cases legislative attempts have been made to clarify the problems. It is apparent, however, that the courts will eventually occupy a major role in delineating specific guidelines.

Diligence

It has been previously mentioned that approved filings for the Upper Colorado River Basin will exhaust the state's entitlement if all those filings are fully developed. Delays in the full utilization of such approved filings have brought up the possibility that sufficient action may never be taken to fully develop these rights.

Historically, extensions of time for full development have been granted as a matter of course. Delays of 50 years are not uncommon. The law states that "reasonable and due diligence" will be shown in fully utilizing approved allocations. Obviously, this statement is subject to wide interpretation. In the past if marginal effort was shown in proving up on a right an extension would be granted. The critical water situation, however, dictates that such latitude may not be in the best interests of current priorities.

The legislature attempted to come to grips with the problem when on May 13, 1975, it passed S.B. 290 which amended Section 73-3-12 of the Utah Code. The act gives to the State Engineer the power to strictly limit extensions of time and requires proof as to the necessity of such extensions. If proof of "reasonable and due diligence" is not shown, the State Engineer, following hearings, is empowered to lapse the filings, thus returning the water to the state for future allocation.

It is difficult to assess the impact of the statute without allowing time for the administrative process to function. Nonetheless, a number of filings, by some estimates up to 100,000 a.f., will be lapsed.

Forfeiture

A second area of concern regarding already allocated water is the issue of abandonment and forfeiture. In this situation, water which has already been allocated and developed is not being utilized. The law specifically mentions the time necessary to define abandonment and forfeiture. Nonetheless, they are primarily judicial decisions and technically difficult to define. Often only a portion of a water right would be subject to such action and this situation complicates the process. Such efforts could, however, provide the state with some new water to allocate to other potential uses.

Priority

The state has seldom departed from the policy of first in filing, first in right, as the guideline for allocating water. This process was adequate when the majority of filings were for the same purposes, namely agriculture. In light of the altered energy picture and continued municipal demands, the question naturally arises whether the use of the filing date as the sole criterion for allocating water is in the best interest of the public.

There are currently on file with the State Engineer literally hundreds of filings, the majority of which are dated after 1950. These filings are for a number of purposes, including energy-related uses. How to deal with these filings will be a major issue in any water policy.

The situation was highlighted in the last legislative session, when a piece of legislation (S.B. 291) was introduced. The bill represented a radical departure from the traditional allocation practices. In essence it would have empowered the State Engineer to decide, without respect to filing date, which filings are most important to the public welfare and, therefore, should be approved. It appears that the primary purpose of the bill was to legislate a ranking of priorities to guide future water allocations. Such a legislative clarification would obviously be easier and faster to obtain than a judicial decision, although that latter route will likely be explored. Although the bill was defeated, it underscores the need in the minds of some people to view future allocation of water in terms of reality.

It appears that the current feeling among the governing officials of the Board of Water Resources and the Governor is that water should be developed, allocated, and managed by a basin-wide entity, similar in scope to a conservancy district. Ideally, particularly in urbanized areas, water allocations should be patterned after public utilities: anyone can sign up for water delivery, water is priced to cover supply cost, and shortages are shared equally.⁴³

As a general policy, public entities seldom participate in water development projects without actually holding title to the water. Since the economic feasibility of such large undertakings is a function of size, the operations naturally require the allocations of significant amounts of water. This situation has some interesting ramifications. If large amounts of water are allocated to the state to develop and distribute to individual users, the state will soon occupy the role of

⁴³Lawrence, "Allocation of Utah's Colorado River Water," p. 93.

water-broker. Individual water rights will be difficult to obtain, and the traditional role of State Engineer may be altered. Obviously then, the state's own water filings will be a significant element in defining a water policy.

In those areas where the Board of Water Resources is able to obtain rights or already holds them, it has been petitioned by other potential users to relinquish parts of those rights. In most cases the Board will attempt to reach some type of agreement for granting a firm agreement for use of the water in place of the actual water right. Such might well be the case with energy demands.

In summary, it appears that definitive action must be taken to reconcile the state's present water allocations with future water demands. Utah is currently utilizing only a part of the state's Colorado River allotment, yet on the books is very nearly over-allocated. Efforts to eliminate abandoned, stale, and inactive water rights could provide some additional water to meet foreseeable demands. The quantification of Indian and federal government rights would also provide a realistic yardstick to evaluate the current water resources available to the state. These rights should not continue to be hypothetically dealt with. Lastly, the formulation of a meaningful criteria to evaluate the vast number of unapproved filings would allow the state to make progress with that situation.

OIL SHALE TECHNOLOGY: WATER NEEDS AND SOURCES

The extraction of oil from oil shale is not new. The Indians of the Upper Colorado River Basin often amazed settlers by showing them examples of the area's burning rocks. In more contemporary times, the extraction of a liquid fuel from shale has been attempted in various ways. None of these previous attempts, however, has approached the magnitude now being contemplated for the oil shale industry in Utah and Colorado.

Utah's oil shale deposits are located in the Uintah Basin and those deposits with the greatest percentage of oil per ton of shale are in eastern Utah near the Colorado State line. Some estimates indicate that 300 billion barrels of oil are contained in these shale reserves.⁴⁴ (See map of oil shale areas)

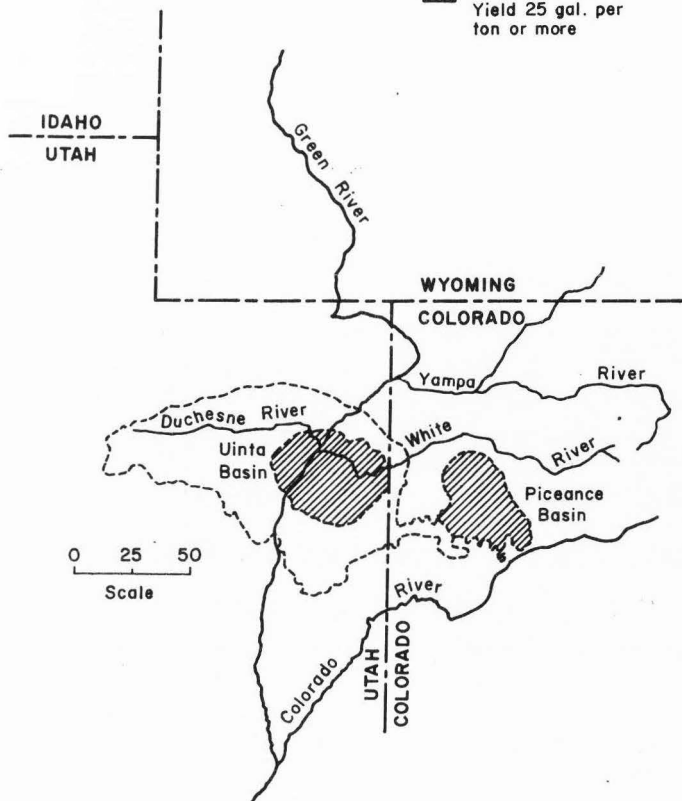
The lands which contain oil shale deposits are owned by the federal government, by the State of Utah, and by private individuals and corporations, and comprise thousands of acres. Ten years ago the State of Utah filed an application to the Bureau of Land Management for In Lieu Selection Rights on 156,000 acres of Federal land. It is expected that title to these lands will pass to the State thereby placing ownership of a substantial amount of these oil shale lands under Utah's ownership.

⁴⁴ The State of Utah Water - 1975 Review Draft, Utah Division of Water Resources, November 17, 1975, p. 53.

LEGEND

□ Low grade or unappraised

▨ Over 15 ft. thick.
Yield 25 gal. per
ton or more



In an effort to determine the feasibility of shale oil as an alternative to liquid petroleum, the Department of the Interior, in 1974, invited bids and awarded leases for prototype oil shale development on tracts which are known as U_a and U_b, located adjacent to the White River. Under the agreements of the lease the consortium of Phillips Petroleum Company, Sun Oil Company, and Sohio Petroleum Corporation, is required to make bonus payments over a five-year period to the Department of the Interior totaling \$120,704,000.⁴⁵

Because of the high costs involved in the development of these prototype tracts, no single company seemingly has the resources to finance the operation independently. Rather, the approach has been to form consortia composed of a number of firms, generally major oil firms, to provide the development expertise and necessary capital and technology. As an example of the tremendous costs involved, one company has estimated that \$200,000,000 will have to be spent before the first drop of shale oil is produced in Utah.⁴⁶

The following pages present a brief description of these consortia, the technology that will most likely be utilized in mining and retorting oil shale, some of the associated water requirements, possibilities for obtaining this water, and some of the problems that are to be expected.

The Development Firms - Colony Development Operation

Colony Development Operation, a joint venture of Atlantic Richfield Co., Shell Oil Co., Ashland Oil Inc., and Oil Shale Corp. has operated a pilot plant to recover oil from shale since 1971 in

⁴⁵Ibid.

⁴⁶Ibid., p. 54.

Colorado. It was thought that the Colony group would be the first group to operate a commercial plant. Their timetable had called for commercial operation to begin near Rifle, Colorado, by 1978. The rising cost of oil shale production coupled with an altered political climate in Colorado which is oriented toward environmental demands, however, forced the Colony organization to suspend indefinitely its project last year.

At the heart of the Colony operation is the retorting method developed by the organization known as Tosco II. Research on the Tosco II method was conducted at the Denver Research Institute for 10 years (1956-66) and under Colony sponsorship a 24 ton/day pilot plant in Colorado has been utilized.

The Tosco process involved the feeding of minus 1/2 inch crushed shale particles into a horizontal rotating retort, where it is heated by mixing with small hot ceramic balls. Shale oil vapors are distilled off, removed, and condensed. The cooled balls and spent shale are discharged from the retort and screened to separate out the balls, which are sent to a heater, reheated, and recycled to the retort. The spent shale is cooled and discharged to compacted waste piles. It normally contains about 4 % of carbonaceous "semi-coke" coating on the particles of spent shale, as discharged.

Paraho Development Corporation - White River Shale Oil Corporation

Sohio Petroleum Co., heads a 17 company consortium known as Paraho Development Corporation, the parent company of Paraho Oil Shale Demonstration, Inc., the operating entity. This group has also operated a small pilot plant at government facilities near Rifle, Colorado.

White River Shale Oil Corporation was formed by three of the sponsoring members of Paraho to develop the lease tracts in Utah. The subsidiary company is currently gathering environmental data in Utah and making plans for development.

The Paraho operation receives its name from the retorting method employed by the consortium. The Paraho process was originally developed by John B. Jones, Jr., who was one of the engineers involved in the original Bureau of Mines pilot project at Anvil Points, Colorado, from 1945-55. After the project shut down, Jones continued his work and development of the process in Brazil.

In the Paraho process the material comes out about the same size and shape as it goes in, lumps which are up to three inches in diameter. It is compacted in a stable land fill that can be covered with the fine gravel not suitable for retort fuel.

The basic unit of the process is the kiln or retort into which the shale is fed. A gas-air mixture heats the shale, driving off the vapors which are collected in the oil recovery unit. Carbon and low BTU gas in the shale help fuel the process. This low BTU gas can supply all the energy needs of the process including generation of electricity. Another by-product of the operation is anhydrous ammonia, which has value as a fertilizer.

Although the two retorting methods have been developed independently, some experts feel that a combination of the Tosco II and Paraho processes will yield the best results. The Tosco method has the capability of utilizing small pieces of shale which the Paraho method does not. The fine grains of shale tend to clog the Paraho kiln. The Paraho method, on the other hand, eliminates the need to

crush the larger chunks into small pieces required in the Tosco operation.

In light of recent progress with the Paraho process and the suspension of the Tosco/Colony operation, the Paraho process will probably be the one employed for the first prototype plants in Colorado and Utah.

Mining

Except for some very recent developments in in situ oil shale production, conventional room and pillar mining is the method which is being contemplated by most involved in the oil shale planning. Open pit and strip mining may have some economic advantages but invoke loud environmental opposition to an industry already sensitive to environmental issues. In addition, most of the rich deposits lie beneath a heavy overburden and are thus inaccessible from the surface.

Water Requirements and Sources

The experimental nature of any oil shale venture means that much of the information regarding cost, environmental impact and other variables is subject to great speculation. The water requirements for the industry fall into this same category.

The latest estimates indicate that a daily production of 100,000 barrels/day from Utah's lease tracts will require at least 26,000 acre feet per year. These same estimates, however, indicate that it may be theoretically possible to lower the water input to a minimum figure of 13,000 acre feet per year. The additional water required by the higher estimate is related to cooling and dust control needs. An additional 4,000 acre feet are expected to be

needed to supply water for the proposed on-site community, if one is built. The Division of Water Resources of the State of Utah has indicated that eventually 75,000 to 100,000 acre feet of water may be needed to support the oil shale industry as all leased lands go into production.⁴⁷

It is difficult to obtain precise information about the water requirements for the individual phases of the oil shale extraction and production processes. Many of the technological advances are closely guarded secrets; the details have not been disclosed by the development firms. The experimental nature of the industry also makes it difficult to obtain accurate estimates.

Bingham Engineering, of Bountiful Utah, the engineering firm commissioned by the State of Utah to investigate the possibility of the White River Dam, has released the following water estimates for the prototype oil shale plant:

Water Requirements
for Oil Shale Lease Tracts U_a and U_b

Minimum Requirement

| | |
|---|-------------------|
| Process Plant. | 9,700 a.f. |
| Processed shale dust control, irrigation and other undefined uses. | 1,600 a.f. |
| Seepage, evaporation and minor losses. | <u>1,700 a.f.</u> |
| Total Practical Minimum Requirement | 13,000 a.f. |

Maximum Requirement

| | |
|---|-------------|
| Minimum Requirement. | 13,000 a.f. |
| Add: Raw water to 100% water cooled process and utility plants | 8,750 a.f. |

(continued)

⁴⁷ Ibid.

| | |
|---|-----------------------|
| Add: Raw water to augment cooling and dust control needs required by different retort processes | 4,500 a.f. |
| Total Probable Maximum Requirement | <u>26,250 a.f.</u> 48 |

The most likely source of water for the oil shale lands in Utah appears to be the White River, which heads in western Colorado above Meeker and is a tributary to the Green River. The confluence with the Green is near Ouray, Utah, about 26 miles south of Vernal. The average annual flow of the White River at the Utah/Colorado line is about 500,000 a.f. Currently the use of the White River is minimal. Colorado uses about 40,000 a.f. for irrigation along the river, and Utah uses a very small amount for lands owned by the Ute Indian Tribe.⁴⁹

Because the river crosses state boundaries, the potential for conflict exists. The Upper Basin Compact limits uses of the waters in the Colorado River system to a percentage basis, as discussed in the last section, but does not specify from which rivers or streams that percentage must be taken. The White River's location is such that it may play an important role in both Utah and Colorado energy development. Obviously some type of compact defining each state's rights to the river would be desirable from a security standpoint. Efforts have been made to obtain such an agreement but results have not been forthcoming and it is thought that such an arrangement might take years to finalize. At the moment all parties are proceeding with development plans on a unilateral basis.

⁴⁸White River Shale Project - Water Supply Alternatives, prepared by Bingham Engineering, Bountiful, Utah, January 1976, p. 4a.

⁴⁹The State of Utah - 1975 Review Draft, Utah Division of Water Resources, November 17, 1975, p. 54.

It should be pointed out, however, that Colorado will probably not be able to use a great amount of White River water and still meet its downstream flow commitments to the lower basin. Colorado is currently utilizing most of its Colorado River allotment and any new use of the White River would have to be coupled with discontinued use of other water. Thus, current water uses in that state seem to restrict use of the White River.

In Utah a number of filings have been made for use of the White River. At the moment none of these filings has been approved. The most important appears to be a 1965 application in the name of the Utah Water and Power Board for 250,000 a.f. Sohio Petroleum Company has also filed for 36,500 a.f. in a 1972 application.

Although the State Engineer has not yet acted upon these and other filings such action must be taken before oil shale will be developed. Although the State Water Board has a priority of seven years over subsequent applications, it appears doubtful that the entire 250,000 a.f. application will be approved. Rather, some accomodation with other energy demands will have to be reached. For example, Sohio has petitioned the Utah Board of Water Resources for an assignment of a portion of the Water and Power Board's application. If the necessary water, some 36,000 a.f., could be segregated for use on 7,592 acres of leased oil shale land, Sohio would withdraw its application. Inasmuch as the Division of State Lands has an enormous potential royalty from the oil shale lands, and in view of the Indian lands situated on the White River, extensive efforts have been made to utilize the White River so as to satisfy both energy, agricultural, and Indian rights and needs.

Proposed Water Development Plans

The most likely alternative for providing water for oil shale development at the prototype tracts in Utah is the construction of a dam on the White River near Watson. Industry officials view the construction of a dam as essential because it eliminates uncertainty about an adequate water supply. It is argued that such a storage project would be necessary regardless of where the water rights should come from, be it from presently unused White River water, agricultural water, or Indian water rights.

The dam and the reservoir are viewed as a multi-purpose operation. Not only would water be supplied for the oil shale tracts, but the dam would provide flood protection, silt retention, and recreational uses. Most important, the project would provide storage for irrigation water to be used on 13,000 acres of Indian lands. The Indian involvement in the project is essential since under the Winter's Doctrine water must be made available to all potentially irrigable acreage. Thus, the Indian Tribe could lay claim to much of the water of the White River without regard to other water uses.

Although the White River dam appears to be the most logical and likely alternative for obtaining water for oil shale, the project would, nonetheless, be an expensive undertaking. Originally construction costs were estimated at \$7,000,000, but have now escalated to \$8,500,000.⁵⁰ It is obvious that the financial arrangements for the project are a major obstacle in the construction of the dam.

⁵⁰Personal communication with Jay R. Bingham, Bingham Engineering and Daniel F. Lawrence, Director, Utah Division of Water Resources.

Several financing alternatives have been proposed. One possibility is to have construction of the project handled under auspices of the Uintah Basin Conservancy District and the Central Utah Conservancy District, with the cooperation of the Ute and Ouray Indian Tribe. Ownership of the water would remain with the state. Oil shale, as well as other users, would then purchase the water as it is utilized.

The exact contractual arrangements for financing the project and delivering the water have not yet been made public, but officials have indicated that some form of public financing is likely. Rather than create a new organization entity, financing would likely be carried out under the Uintah Conservancy District since it involves working with only one county. Funds would be obtained in the form of revenue bonds with the conservancy district floating the bonds to obtain better interest rates. The exact price of water for oil shale has not been decided, but discussions with state and construction officials indicate that the figure will likely fall between \$25 and \$35 per acre foot. Agricultural water would be priced significantly below these figures.

Another possibility would be to have the oil shale consortium itself build the dam. Under the terms of the lease agreements with the federal government on the prototype tracts, the consortium is entitled investment credits in the fourth and fifth years. Thus, it may elect to build the dam itself and write the expenses off to these investment credits.

Both of these previously mentioned possibilities incorporate the idea of a significant involvement by the oil shale industry in the construction of the White River dam. Indeed, the project's initial focus was to provide water for oil shale. However, because of the

project's potential benefits for groups other than those in oil shale, especially the Ute and Ouray Indian Tribe, state officials indicate a willingness to examine the feasibility of constructing the White River dam without oil shale's participation. In an interview with Daniel F. Lawrence, Chairman of the Utah Division of Water Resources, he indicated that if the future of oil shale were to grow more uncertain the possibility exists that the State of Utah might be asked to appropriate the money for the construction of the dam. Mr. Lawrence in essence stated that the White River dam should be examined on its own merits without regard to the future of oil shale.

Efforts to build the White River dam without the oil shale industry's participation appear primarily geared toward satisfying the Indian water needs. Indeed, regardless of whatever means of financing the project is decided upon, the Indian water rights will likely be heavily subsidized either by oil shale or the state. The reasons for this action are essentially political. The Ute and Ouray water rights on the White River are not part of the deferred water rights under which the Central Utah Project operates. Nonetheless, they are water rights which the Indian Tribe is entitled to develop. Efforts to satisfy these rights could have a positive effect on Indian participation with regard to the remaining units of the Central Utah Project as well as other water developments in Eastern Utah. It, therefore, appears likely that about half of the storage in the White River dam reservoir will be Indian water. Various proposals would give the Indians a third to a half equity in the reservoir. Mr. Lawrence indicated that the possibility of obtaining funding from the Four Corners Regional Council as well as other sources for the funding of the Indian involvement is being investigated.

Nonetheless, much of the impact of the White River dam will be to satisfy Indian demands to insure Indian participation in other water development projects.⁵¹

In summary, no concrete proposals for the development of the White River dam have been finalized as yet. Efforts are currently under way to complete a memorandum of understanding between all the interested parties as well as a commitment from the state, the conservancy districts and the Indians to aid in the financing of the preliminary studies to be done on the project.

The role of oil shale is still cloudy, and negotiations are currently under way by the companies to obtain extensions of time with regard to the investment schedule on which they must prove up on their leases. TOSCO and Moon Lake Electric, an electric-power company with interests in developing the area's coal deposits, have also petitioned to be involved in the White River dam project. Their water needs must also be evaluated with regard to the water capacity of the project. It also appears likely that the State Engineer's office will approve the petition to segregate a quantity of the Utah Power Board's filing for development on the White River. The original request was for the segregation of 36,000 acre feet. However, it is likely that some 53,000 acre feet will be segregated for energy-related development.

According to Jay R. Bingham Engineering, the firm contracted by the State Board of Water Resources to survey the possibilities of the dam, work is currently being completed on the environmental impact study and test drilling for the foundation is 50% completed.

⁵¹Personal communication with Daniel F. Lawrence, Director, Utah Division of Water Resources.

Bingham also indicates that the dam may have to be one of the first items built for the proposed oil shale complex. Blowers necessary for the retort have to be transported to the site. The most economical method is to transport these blowers intact. Since the weight of the blowers, approximately 700 tons, exceeds the capacity of all existing bridges in the White River area, the dam would have to be constructed first to provide a means of transporting the heavy equipment. Because of this situation and if all other aspects of the planning go as scheduled, the engineering firm estimates that the construction on the dam could begin within a year and a half to two years.

The construction of the proposed White River dam is symbolic of the major obstacle for a commercial oil shale plant; astronomical costs. It is estimated that the dam alone would cost \$8,500,000 and that the total costs for the entire commercial module could approach \$1.5 billion. These costs must also be viewed in light of other financial obligations besetting members of the White River consortium. Sohio Petroleum, for example, has an obligation of \$1 billion for its share of the Alaska pipeline.⁵² It comes as no surprise then that the White River Oil Shale Corporation is attempting to shift some of this financial burden to other investors.

The economic feasibility of such mammoth projects is closely tied to the market price for crude oil. Exact figures are not available as to what oil price would make oil shale feasible, but it is safe to assume that the price is higher than the current free market figure for crude.

⁵² Ibid.

The availability of funds and the sharply rising costs of construction and equipment are also clouding oil shale's future. To offset this problem of lack of adequate venture capital, some groups such as Colony Development, have attempted to obtain long-term, low interest federal loans for their projects. They've also attempted to receive some form of guaranteed price support for petroleum to insure an adequate return from an oil shale operation. To date all such efforts have proven unsuccessful but are no doubt continuing.

Officials once felt that work on the commercial plant may begin by 1977 and that by 1980 three commercial units, two in Colorado and one in Utah, could be in operation. However, the time schedule for the entire project is currently under an indefinite holding pattern. Whether it will even be attempted is the subject of great speculation. If a prototype plant is completed, there are no present plans to extend capacity beyond a 100,000 barrel/day limit.

POPULATION IMPACTS

The information in the last section on water for oil shale indicates that the proposed White River dam could provide water for the prototype operation without infringing upon existing agricultural water supplies. Domestic water supplies for the increased population associated with oil shale growth may present some problems, however. Although present plans indicate that some 4,000 additional acre feet will be requested to supply municipal water, there are no guarantees that all or any of the oil shale population will locate on-site. If a new town is not built existing communities will have to absorb the population growth. In that case will the communities be able to supply domestic water without affecting the agricultural sector?

It is the purpose of this section to examine the population growth associated with the proposed oil shale plant and the necessary water needed to supply this population increase.

It is important to distinguish between water "demand" and "requirement." The term "requirement" implies a fixed need for water where the quantity utilized is quite independent of the price of water. Need is related to water-using technology, to crop requirements in irrigation, or to the population using water. Demand, on the other hand, is a specialized term utilized by economists to express the relationship between quantity of water used at various relative prices of water. One measure of the degree of responsiveness of the quantity demanded to changes in the relative price of water is known as elasticity of demand.

It is generally assumed that the demand for domestic water is relatively inelastic; i.e., that there is little alternation in water consumption as a result of price changes. Empirical studies have indicated, however, that the household demand for water is indeed affected by price changes as well as other factors. For example, Gardner and Schick⁵³ found the elasticity of demand for household water to be $-.77$. People in communities with high prices consumed less water per capita than people in communities with low prices. As among 44 northern Utah communities an increase in the price of water of 10 percent was associated with a per capita decrease in the quantity consumed of 7.7 percent. It was also discovered that uses such as lawn and garden watering were particularly responsive to rate changes. When municipal prices are high, development of other water supply sources becomes economically attractive, and people find various ways to conserve water use.

This response of consumption to price may be important in establishing water use figures for such communities as Vernal, Utah, where water has generally been plentiful and cheap. Consumption figures indicate that water use for domestic purposes has been relatively high when compared with national household consumption estimates. Increases in the rates charged for water demanded by municipal consumers may make more water available for other uses.

The population increase connected with all aspects of Utah's energy resources has been an area which has attracted great public

⁵³B. Delworth Gardner and Seth H. Schick, Factors Affecting Consumption of Urban Household Water in Northern Utah, Bulletin 449, Agricultural Experiment Station, Utah State University, Logan, Utah, November 1964.

interest. Every community located near untapped energy resources anticipates the economic benefits associated with such development. The majority of these communities also seem to be anticipating some of the problems associated with this growth.

Since the plant capacity estimated for the prototype operation has continually fluctuated, it has been difficult to establish what the exact population increases will be. As recently as November 1974, in their task force report for Project Independence prepared for the Federal Energy Administration, the Department of the Interior estimated that a 100,000 barrel/day prototype operation would involved a total oil shale population of 24,400 people by 1980.⁵⁴ This same study also estimated that accelerated development would involve over 90,000 people by the year 2000.⁵⁵ Of course, these figures reflect the belief that future oil shale development would far surpass the prototype capacity of 100,000 barrels/day at some later date.

Projecting the population distribution for the oil shale population is also a difficult task. It was originally thought that a majority of the population would locate in the Ashley Valley-Vernal area with the rest being disbursed throughout the Uintah Basin. Subsequent studies, however, have indicated that Rangely, Colorado, located only 30 miles from the proposed site, would absorb a large share.

The possibility of a new town being constructed near the present town of Bonanza, Utah, would eliminate the need for the oil shale population to locate in existing communities. If such a new town is

⁵⁴"Project Independence," Task Force Report, U.S. Department of the Interior, November 1974, Table H-5, p. 193.

⁵⁵Ibid.

constructed, it would have to include all the necessary facilities to attract the oil shale work force.

In light of the current status of oil shale development in Utah, namely no immediate plans for expansion beyond a 100,000 barrel/day capacity, population estimates have been scaled down. In a 1975 publication, Lewis estimates that the total population increases associated with oil shale development for the Utah lease tracts will not exceed 13,780, with a final commercial operational estimate of 12,535.⁵⁶ If plans for the unit begin in 1978, the increased population will not become a factor until the fifth year of 1983. The eighth year represents the high point in population increase.

The population figures presented by Lewis indicate that the majority of the anticipated population, assuming no new town is built, will locate in the Vernal, Utah, and Rangely, Colorado, areas. Duchesne and Roosevelt, located in Duchesne County, Utah, would also receive an increase in population, however.

The figures indicate that Vernal would anticipate a final population increase of 3,958, Rangely an increase of 5,396, and Roosevelt and Duchesne increases of 1,574 and 479 respectively.⁵⁷ Even if the new town is not built there will still be a considerable on-site population. It is estimated that 30 % of the construction force and 10 % of the operations force would live at or near the construction site.⁵⁸

⁵⁶W. Chris Lewis, Socio-Economic Impact Study of Oil Shale Development in the Uintah Basin, Western Environmental Associates, 1975, Logan, Utah.

⁵⁷Ibid.

⁵⁸Ibid.

If the new town is built, it will capture the majority of oil shale population. Lewis estimates that the town would have a final population of 10,028 with an 8th year high of 11,024. Approximately 80 percent of the oil shale population would locate in the new facility.⁵⁹ The remaining people would locate throughout the Uintah Basin. Vernal and Rangely would capture the great majority of this non-new town population. Roosevelt and Duchesne's population increase would be negligible.

Water Needs

The Board of Water Resources has stated that 4,000 acre feet will be petitioned by the White River Oil Shale Corporation to supply adequate municipal water. This amount would be in addition to 26,000 acre feet requested for industrial requirements. If a consumption rate of .25 acre feet per capita is used (this represents a rate of 225 gallons per capita per day and is the rate generally used by the Project Independence Task Force Report) there would be enough water to support a population of 16,000 people on-site. This is more than is projected in the Lewis population estimates.

Using these same water consumption estimates and population figures for the population distribution without the new town, the water "requirements" for the Vernal area can be indicated. (See Table 3) The Vernal figures are the only ones shown since that is the only Utah area with a considerable projected population increase. The same procedure would hold true for the other areas, however. The population table indicates that there will be a population increase of 4,010 in the eighth year of development. Using the .25 acre foot

⁵⁹Ibid., p. 30.

per capita consumption estimate the water requirement for that population increase is approximately 1,000 acre-feet of water.

One of the primary concerns of rural communities located within the oil shale area is that this additional water will be taken from existing agricultural supplies. Although it will be shown later in this report that there are a number of potential sources of domestic water, for the sake of argument, let it be assumed that all the additional water would be withdrawn from agriculture. How much agricultural land would be affected?

Using an annual irrigation diversion figure of 3.0 acre feet/acre, in the eighth year, which is the high population year, only approximately 335 acres would need to be removed from irrigation to supply the needed increase in domestic water needs. Thus, it would appear to require the sacrifice of very little agricultural acreage to supply the water for a significant population increase. This statement ignores the fact that water quality needs for domestic uses may not be satisfied through the simple transfer of irrigation water to municipal uses. Obviously some treatment of the water would be required or an exchange arrangement reached where communities could substitute the irrigation water for high quality water. Again, it should be mentioned that this transfer situation is hypothetical and there are still other ways to obtain sufficient water without substantial direct withdrawal from agricultural sources. These other alternatives for the Vernal area will be discussed in the next section.

The New Town

Obviously, if a new town is built, a great deal of the concern currently felt by existing communities about absorbing the oil shale

population will be alleviated. Whether the new town will in fact be built is uncertain at present. Vernal and Rangely are located less than 40 miles from the proposed oil shale site, and highway improvements could shorten that distance, both in miles and in trip time. Even if the new town is built, however, there will still be a close association between the new town and these two communities. A second consideration is that the new town may not be of permanent duration. It may exist only for the oil shale industry and once the shale is fully exploited the need for the town may disappear. Since the shale deposits are so extensive, however, the town may last for a very long time. Whether the high cost of the construction of the new town would offset transportation costs to and from Vernal and Rangely is debatable. Each depends on how long the new town can be assumed to last and over what period the capital costs can be amortized. One thing is fairly obvious, U_a and U_b are located in a desolate desert without the natural geo-physical features that would make a new town an attractive place to live. There would have to be some real incentive to make people locate there.

Water Sources for Duchesne and Roosevelt

The information presented in the Lewis population estimates indicates that Vernal, Utah, will capture the bulk of the oil shale population to locate in Utah. These same figures also indicate that Roosevelt and Duchesne will receive a relatively small population increase. The following section will examine in depth the sources and water needs for the Vernal, Ashley Valley area. The water sources for Roosevelt and Duchesne will be briefly outlined here.

Roosevelt, the larger of the two Duchesne County communities, obtains its domestic water from the following sources:

1. Uriah Heaps Spring - piped from the spring near Whiterocks. The spring is Indian owned and has a capacity of 1,000 gallons per minute (1614 a.f./yr). The spring was the sole source for Roosevelt culinary water until October 1975.
2. Hancock Cove Well - developed and started to use in October 1975. Capacity is placed at 1.2 c.f.s. per minute (864 a.f./yr).
3. Campbell Well - the rights have been cleared and development is anticipated by 1976. Preliminary estimates of capacity indicate a rate of 4.5 c.f.s. - (3240 a.f./yr).

The system now has two 500,000 gallon storage tanks and will add a one million gallon tank with the Campbell well. Extensive remodeling and replacement of old lines has taken place throughout the system resulting in a savings of about one-third in water used. It is estimated that the two wells will double the supply and that present commitments will be adequate for a population of 10,000 unless considerable water-using industrial development takes place. That prospect appears unlikely at present. Should additional needs arise they will most likely be met by additional wells.⁶⁰

In 1960, Duchesne City began a major water system improvement program. The program included the development of new wells, the construction of a desander/chlorinator facility, new transmission and supply lines, a reinforced concrete reservoir and an entirely new distribution system. In 1971, a new pump house, a steel storage tank, and a high-level distribution system were constructed to bring water from the lower elevations of Duchesne to the "Blue Bench" area.

⁶⁰Personal communication with Larry Bagley, Roosevelt City Manager and Leon C. Michaelson, area coordinator, Cooperative Extension Service, Utah State University.

The primary source of water for the community is six shallow wells located in the Murray Springs area three and a half miles north of town. Two additional wells have been recently completed in the area. It is estimated that all eight wells pumping simultaneously will produce 1,000 gallon/minute, or 2.23 cubic feet per second. (1614 a.f./yr)

Other potential sources of water are two springs on Rock Creek located 25 miles northwest of the town. Starvation Reservoir, located three miles from town, and the Duchesne River which passes through Duchesne City. In 1905, the federal government filed an application to appropriate 15 c.f.s. from the Duchesne River for municipal purposes. There is some controversy over the application, however, and the State Engineer's Office maintains that water rights in question are owned by the U.S. Bureau of Indian Affairs. Legal action is pending to establish ownership of the water.⁶¹

Legal action to establish title to the disputed right on the Duchesne River appears imperative for the community to develop an adequate future water supply. The eight wells in the Murray Springs area are sufficient to satisfy a population of 3,300 people at present consumption levels.⁶² Improvements in storage facilities would also eliminate existing storage deficiencies.

In short, current water supplies appear adequate to satisfy the needs of the projected population increase if rights to the Duchesne River are clarified. Without that, efforts would have to be made to obtain water from Starvation Reservoir or other sources which might

⁶¹Report on Duchesne City Water prepared by Valley Engineering, February 1975, p. 3.

⁶²Ibid., p. 4-5.

have an effect on agriculture if the community were to undergo substantial population increase. The population figures in this study, however, assume the increase from oil shale to be rather small.

Upalco and Uintah Units of the Central Utah Project

These two units of the Central Utah Project, if completed, would provide more than enough water to satisfy any substantial population increase. The Uintah Unit would provide 52,000 acre feet of municipal, industrial, and agricultural water to the Roosevelt area. The project also includes water for 42,000 acres of Indian land. The Upalco Unit would be located near the center of Duchesne County and would provide 20,500 acre feet of new water for municipal, industrial, and agricultural purposes.⁶³

The future of the two units is far from certain, however. Both projects appear to have a low priority behind already promised but as yet uncompleted water projects. In their favor is the importance of satisfying Indian rights. It was mentioned in an earlier section that the Indian demands must be satisfied or further construction on the Central Utah Project faces the possibility of indefinite suspension. The development of the Upalco and Uintah Units, therefore, may be determined by what pressures can be brought to bear by the Indians and industry.

⁶³Eleventh Annual Report of the Central Utah Water Conservancy District, prepared by the Central Utah Water Conservancy District, 1975, p. 8-9.

WATER SOURCES FOR THE VERNAL-ASHLEY VALLEY AREA

The information presented in the last section indicates that Vernal-Ashley Valley will be the area of the State of Utah to realize the greatest direct impacts from the prototype oil shale operation. Even if all the needed water for the population increase associated with a 100,000 barrel/day prototype plant were to come from agricultural supplies it would only involve an amount sufficient to irrigate some 300 acres. Nonetheless, if energy development in the area were to be undertaken on a large scale, that situation could easily change.

The purpose of this section of the report is to investigate the current water usage in the Vernal-Ashley Valley area and to examine alternative plans for obtaining water for agriculture and municipal and industrial uses.

Current Water Sources

There are two public water systems that currently operate within the boundaries of the Ashley Valley. These are the Maeser and Ashley Valley-Vernal systems. The supply source for both systems is the Ashley Springs, located adjacent to Ashley Creek nine miles north of Vernal. (See map of Maeser-Ashley Valley-Vernal water systems)

From the Spring Box and the adjacent sedimentation and chlorination works, the water flows southward into Ashley Valley. Water lines have been laid adjacent to the roads along section boundaries. This system provides water service to most of the developed areas in the

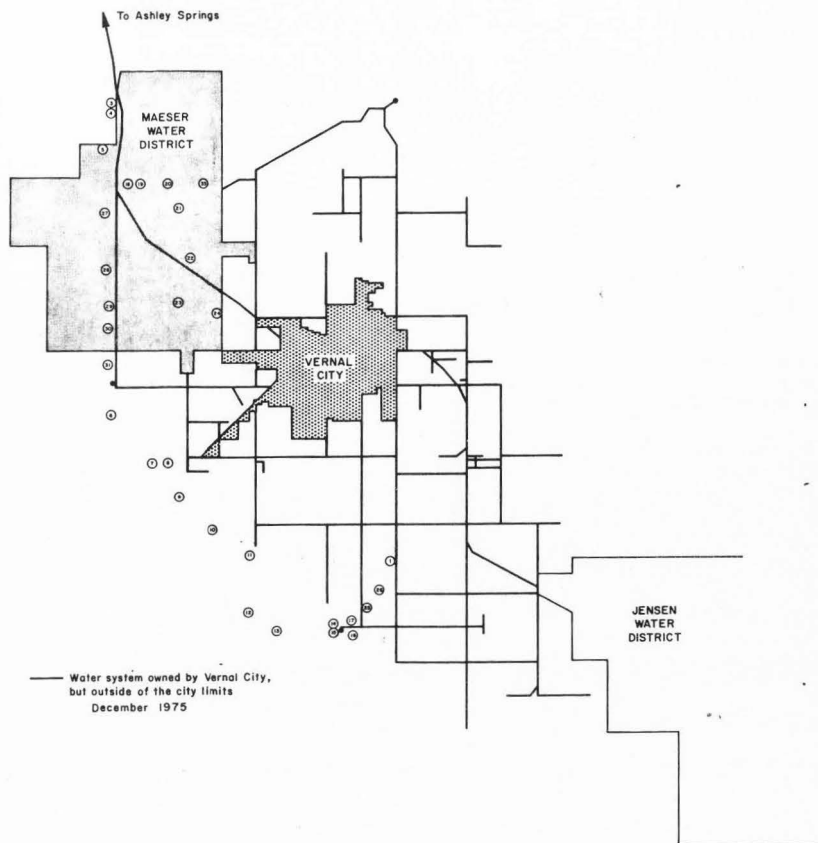


Table 1. Gravity model distribution of population impact among principal urban places in the Uintah Basin assuming no new town is constructed

| Year | Cumulative Total Population Impact | Duchesne ^{a/} | Roosevelt ^{a/} | Vernal ^{a/} | Rangely ^{a/} | At or Near Site | Other Parts of Uintah Basin ^{a/} |
|------------------|--|------------------------|-------------------------|----------------------|-----------------------|--------------------|--|
| Commercial Stage | | | | | | | |
| Phase I | | | | | | | |
| 5 | 4,538 | 152 | 500 | 1,257 | 1,713 | 688 | 227 |
| 6 | 6,218 | 206 | 678 | 1,704 | 2,324 | 994 | 311 |
| 7 | 8,277 | 277 | 911 | 2,290 | 3,121 | 1,265 | 414 |
| 8 | 13,780 | 485 | 1,595 | 4,010 | 5,466 | 1,536 | 689 |
| 9 | 11,310 | 419 | 1,376 | 3,461 | 4,718 | 770 | 566 |
| 10 | 10,902 | 412 | 1,354 | 3,405 | 4,614 | 545 | 545 |
| Commercial Stage | | | | | | | |
| Phase II | | | | | | | |
| 11-15 | 12,535 | 479 | 1,574 | 3,958 | 5,396 | 501 | 627 |
| 16-20 | 12,535 | 479 | 1,574 | 3,958 | 5,396 | 501 | 627 |

a/ Gravity proportions for distribution of urban population

| | |
|-----------|-------|
| Duchesne | 0.042 |
| Roosevelt | 1.138 |
| Vernal | 0.347 |
| Rangely | 0.473 |

b/ Basic assumptions for on-site population projections:

1. 30.0 percent of the construction force would live in the construction camp at or near the site.
2. 10.0 percent of the operations force would live at or near the site.

c/ Five percent of total population impact is allocated to non-urban parts of the Uintah Basin.

Table 2. Gravity model distribution of population impact with new town

| Year | Population Impact | New Town ^{a/} | Duchesne ^{b/} | Roosevelt ^{b/} | Vernal ^{b/} | Rangely ^{b/} | Other Parts of Uintah Basin ^{a/} |
|------------------|-------------------|------------------------|------------------------|-------------------------|----------------------|-----------------------|---|
| Commercial Stage | | | | | | | |
| Phase I | | | | | | | |
| 5 | 4,538 | 3,630 | 36 | 119 | 299 | 408 | 45 |
| 6 | 6,218 | 4,974 | 50 | 163 | 410 | 559 | 62 |
| 7 | 8,277 | 6,622 | 66 | 217 | 546 | 744 | 83 |
| 8 | 13,780 | 11,024 | 110 | 361 | 909 | 1,238 | 138 |
| 9 | 11,310 | 9,048 | 90 | 297 | 746 | 1,016 | 113 |
| 10 | 10,902 | 8,722 | 87 | 286 | 719 | 980 | 109 |
| Commercial Stage | | | | | | | |
| Phase II | | | | | | | |
| 11-15 | 12,535 | 10,028 | 100 | 329 | 826 | 1,127 | 125 |
| 16-20 | 12,535 | 10,028 | 100 | 329 | 826 | 1,127 | 125 |

a/ Based on an 80.0 percent capture rate for the new town.

b/ Gravity proportions for distribution of urban population outside "new town:"

Duchesne 0.042

Roosevelt 0.138

Vernal 0.347

Rangely 0.473

c/ Five percent of population impact outside new town is allocated to non-urban parts of the Uintah Basin. (The sum of individual population impacts may not equal total impact (column 2) due to rounding.)

⁶⁵W. Chris Lewis, Socio-Economic Study of the Oil Shale Development in the Uintah Basin, Western Environmental Associates, 1975, Logan, Utah, p. 29.

Table 3. Water needed to support oil shale population and potential agricultural acreage affected in the Vernal area assuming no new town is constructed

| Year | Population Impact | Water ^{a/} Needed | Acreage ^{b/} Affected |
|---------------------------------|----------------------|-------------------------------|-----------------------------------|
| Commercial Stage Phase I | | | |
| 5 | 1,257 | 314.25 | 104.75 |
| 6 | 1,704 | 426.0 | 142.0 |
| 7 | 2,290 | 572.50 | 190.8 |
| 8 | 4,010 | 1002.5 | 334.2 |
| 9 | 3,461 | 865.25 | 288.4 |
| 10 | 3,405 | 851.25 | 283.75 |
| Commercial Stage Phase II | | | |
| 11-15 | 3,958 | 989.50 | 329.8 |
| 16-20 | 3,958 | 989.50 | 329.8 |

^{a/} Based on estimate of .25 acre feet per capita

^{b/} Based upon estimate of 3.0 acre feet per acre

Table 4. Water needed to support oil shale population and potential agricultural acreage affected in the Vernal area assuming new town is constructed.

| Year | Population Impact | Water ^{a/} Needed | Acreage ^{b/} Affected |
|---------------------------------|----------------------|-------------------------------|-----------------------------------|
| Commercial Stage Phase I | | | |
| 5 | 299 | 74.75 | 24.9 |
| 6 | 410 | 102.5 | 34.16 |
| 7 | 546 | 136.5 | 45.5 |
| 8 | 909 | 227.25 | 75.75 |
| 9 | 746 | 186.5 | 62.16 |
| 10 | 719 | 179.75 | 59.9 |
| Commercial Stage Phase II | | | |
| 11-15 | 826 | 206.5 | 68.83 |
| 16-20 | 826 | 206.5 | 68.83 |

^{a/} Based on estimate of .25 acre feet per capita.

^{b/} Based on estimate of 3.0 acre feet per acre.

upper Ashley Valley. In the cities, the Vernal and Maeser water systems provide water service to all developed areas within the respective communities. These two systems are an integral part of the Ashley Valley system.

At the time the larger Ashley Valley system was developed in 1961, most of the then existing lines, including those in Maeser and Vernal, were incorporated into the system. Under terms of the agreement, Maeser Improvement District obtained a one-eighth interest in the supply aqueduct, headworks, and treatment facilities. The district is still responsible for maintaining and administering that part of the distribution system within its boundaries. The remainder of the Ashley Valley Water System is owned and maintained by Vernal City.

The present population served by the Springs would include Vernal City, all of the area outside of the Vernal City limits within Ashley Valley connected to the system, the Maeser Water District area (this is the northwest corner of Ashley Valley), and the Jensen area. The following number of connections currently exist on the total system: (30 Nov. 1975 estimate)

1670 - Inside Vernal City

1620 - Outside Vernal City, but on the City's system

460 - Maeser District area

120 - Jensen⁶⁶

Maeser sets its own rates which are comparable to Vernal City's rates. For those outside of Vernal City but on its system, the rates are approximately double the rate charged inside the City.⁶⁷

⁶⁶Water and Sewer Plan Uintah County, Utah, Uintah County-Vernal City Planning Commission, September 1970, p. 35.

⁶⁷Ibid.

According to the Water and Sewer Plan for Uintah County prepared by Despain Planning Associates in 1970, and the Vernal City records, water rights held by Vernal City for water through the line from Ashley Springs include:

1. Steinaker Reservoir storage which the city exchanged for Ashley Springs water in the amount of 1,400 a.f. divided as follows:
 - a. 750 a.f. - Vernal City in its own right.
 - b. 200 a.f. - Transferred to Vernal City by Naples Water Company.
 - c. 150 a.f. - Transferred to Vernal City by Ashley Water Company.
 - d. 300 a.f. - Transferred to Vernal City by Glines-Davis Water Company.

The water is available on a year-round basis.
2. Ashley Central Irrigation Company Water Stock (Mutual Irrigation Company) totalling approximately 4,112.95 a.f. This water is available year round.
3. Ashley Upper Irrigation Company Water Stock (Mutual Irrigation Company) which is equal to approximately 34.30 a.f. available year round.
4. Ashley Valley Reservoir Company Water Stock totalling approximately 503.52 a.f. available year round.
5. Diligence Rights Claim No. 1370, for 3.5 c.f.s. (2529 a.f./yr) from Ashley Springs on a year-round basis.
6. Application to Appropriate Water for Municipal Purposes No. 24219 (not yet perfected) for 5 second feet (3600 a.f./yr) from Ashley Springs for use from October to April.
7. Application to Appropriate Water for Municipal Purposes No. 24341 (not yet perfected) for 2,000 a.f. on a year round basis from Ashley Springs by exchange from Ashley Creek and Trout Creek Reservoir.

The Maeser District also holds rights to the Ashley Springs water. These rights include some 200 a.f. of storage water in Steinaker Reservoir used for exchnage for water diverted into the system from the Springs for use during the irrigation season and stock in the Ashley Upper and Central Irrigation Companies amounting to 460 a.f.⁶⁸

⁶⁸ Ibid.

Based upon the information presented above, rights currently held by Vernal City and the Maeser District provide access to 9,244 a.f. of water. This total does not include amounts from the unperfected rights. Also, the area may not have full use of Diligence Right No. 1370 for 2,533 a.f. since it is subject to other prior rights. Thus, Ashley Valley has clear and unrestricted use to 6,710.77 a.f.

The current population of Ashley Valley is approximately 13,700. The basis for this estimate is a housing study and actual housing count taken in December 1974, and continually updated. Therefore, based on current population and water figures, the residents of Ashley Valley have access to .49 a.f. of water per capita. If the water from Diligence Right No. 1370 is included, the figure jumps to .69 a.f. per capita.

According to most sources, including local community leadership, flow from the springs is more than adequate to meet the needs of the area's residents. At present use rates and water prices, the springs alone would be able to supply triple the demands of the current population.⁶⁹ There are also indications that current use in the valley is unusually high. In 1974, the average annual consumption of water within the Vernal City system was .49 a.f. per capita. Most studies indicate a figure of .25 a.f. per capita is indicative of national domestic water consumption patterns. The previous chapter's discussion on the response of water use to price may suggest

⁶⁹ Final Environmental Statement for the Authorized Bonneville Unit, Central Utah Project, Utah. Prepared by the Bureau of Reclamation, Dept. of the Interior, August 2, 1973. p. 406.

that per capita use would decline in response to higher water rates. Also, older parts of the water system need to be repaired and improved and, if done, water waste could be prevented.

Thus, it appears that high quality water supplies are available for projected domestic uses. The problem arises in acquiring the rights to use that water. Agricultural rights presently encompass the majority of the flow rights from Ashley Springs. Therefore, a transfer of water from agricultural uses to municipal uses would necessitate a transfer of right.

According to the Vernal City Manager, steps have already been taken to insure the transfer of agricultural water used on land that has been or would be taken out of agricultural production and incorporated in the city for municipal purposes. Vernal City presently requires water stock ownership to be transferred to the City for each water connection added "where there exists water rights attached to the property desiring to be served with the new water connection." This water stock is actually shares held in the various canal companies which exist in the area referred to earlier in this section.

The City pays \$45 for the water stock required for a culinary water connection. The fraction of a share required to provide this water is different for each individual irrigation company since a share in one company does not involve the same amount of water as in another company. The fractions required are as follows:

1. Ashley Central - $1/20$ th share
2. Ashley Upper - $1/10$ th share
3. Ashley Valley Reservoir - $2-1/4$ shares
4. Island Ditch Company - 1 share
5. Rock Point Canal Company - $1/8$ th share

All these fractions have equal value in terms of acre feet of water.

Whether or not this amount represents fair compensation is a difficult matter to determine. According to local officials the figure of \$45 was arrived at by a fair market value determination by members of the Ashley Valley Water Users Association. Discussions with local irrigation officials indicate that the amount reflects the current prices which water shares are being sold for in the area. However, the prices which energy developers could pay for this water might be considerably higher. The present holders of rights understand this and translate it into an expectation that water prices may rise. The evidence in this study, however, is that this expectation may well be unfounded unless large-scale commercial operations begin.

Another area of concern is obtaining adequate rights for approved exchange purposes so that the higher quality water from the Ashley Springs can be available for municipal and industrial uses. Thus, plans call for the city to get rights for water to be developed under the Jensen Reclamation Project of the Central Utah Project. This is discussed below.

The courts appear to be one avenue being explored by both Vernal City and local agricultural users to define water rights and powers of communities to obtain these rights. There are a number of cases pending before local and state courts to define and settle various disputes over water usage. Some even involve potential condemnation of water for public purposes in order to supply domestic needs.

In summary, there appears to be excess water from the Ashley Springs to supply the oil shale population over and above the quantity

supplied to the existing agricultural sector. Nonetheless, in the event of continued population growth Vernal City will have to take measures to insure that this excess water is transferred to the city.

The Central Utah Project - The Vernal Unit

The Vernal Unit (see map of Vernal Unit) provides irrigation and municipal water to Ashley Valley and is essentially complete. The unit has been supplying water to the valley for more than ten years.

The major features of the unit are the Steinaker Dam and Reservoir, Fort Thornburgh Diversion Dam, Steinaker Feeder Canal, and Steinaker Service Canal.

Water is diverted from the Ashley Creek at Fort Thornburgh Diversion Dam some two miles west of Maeser and delivered to Steinaker Reservoir by the feeder canal. The unit supplies about 18,000 a.f. of water each year for supplemental irrigation and about 1,600 a.f. for municipal use. This water is used as exchange water for flow from Ashley Springs. All water is currently purchased and is presently being utilized.⁷⁰

The supplemental water supply firms up the previous undependable supply, and in particular late irrigation season water, to about 15,000 acres of cultivated land. The 1,600 a.f. of municipal water is sufficient to provide water for 3,300 persons at a consumption rate of .49 acre feet per capita.⁷¹ The Green River is depleted by 12,000 a.f. per year as a result of the Vernal Unit. This results from reservoir evaporation, domestic use, and irrigation consumptive use.

⁷⁰Ibid., p. 407.

⁷¹Ibid., p. 410.

The Jensen Unit

The Jensen Unit (see map of Jensen Unit) will provide additional irrigation water for the Jensen area and augment municipal water supplies to the Ashley Valley-Vernal City area. The unit was scheduled for construction in 1974, but environmental and economic problems have hampered its beginning. Most of these problems have now been resolved, and on May 25, 1976, voters in the Uintah Water Conservancy District overwhelmingly approved the \$33,000,000 commitment to the Federal Government to get construction on the unit started.

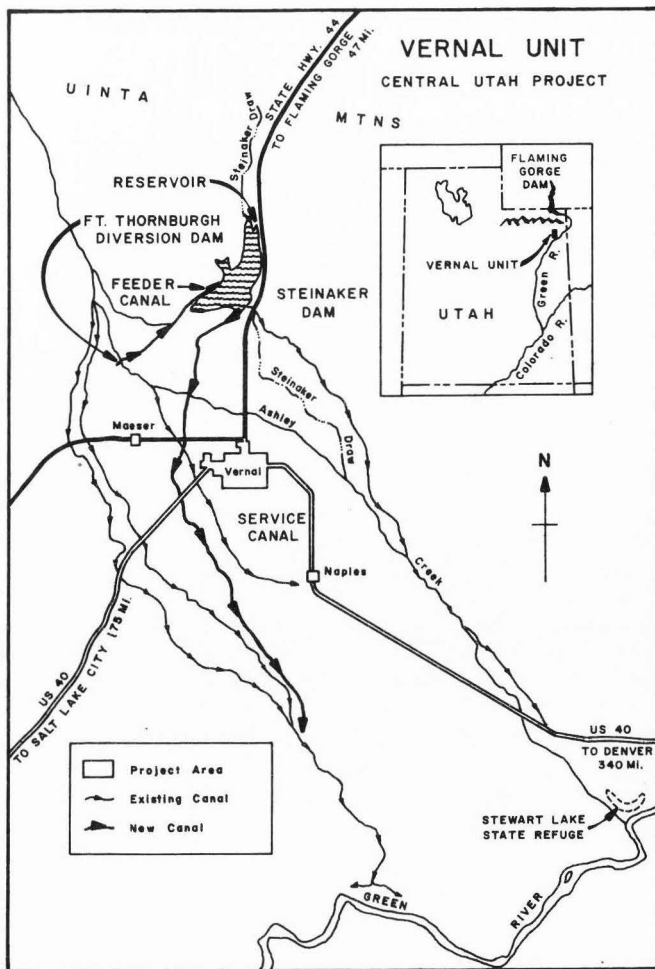
The main features of the unit will be the Tyzack Dam and Reservoir, Aqueduct, Pumping Plant, and the Burns Pumping Plant. The dam and reservoir will be located on Big Brush Creek approximately 3 miles south from the Utah Highway 44 crossing.

The unit will develop 4,700 acre feet of water for irrigation purposes in the Jensen area, and 18,000 acre feet for municipal and industrial purposes in the Ashley Valley area.⁷² Plans call for the immediate purchase of 7,200 acre feet of municipal water by Vernal City with additional purchases when needed. This 18,000 acre feet would provide the water to meet the domestic demands of 38,000 additional persons at a consumption rate of .49 acre feet per capita.⁷³

To transfer the municipal water from the proposed reservoir to Vernal a four-mile buried aqueduct will be constructed. The water would be pumped over the ridge to the west of the reservoir and

⁷²Ibid., p. 411.

⁷³Ibid.

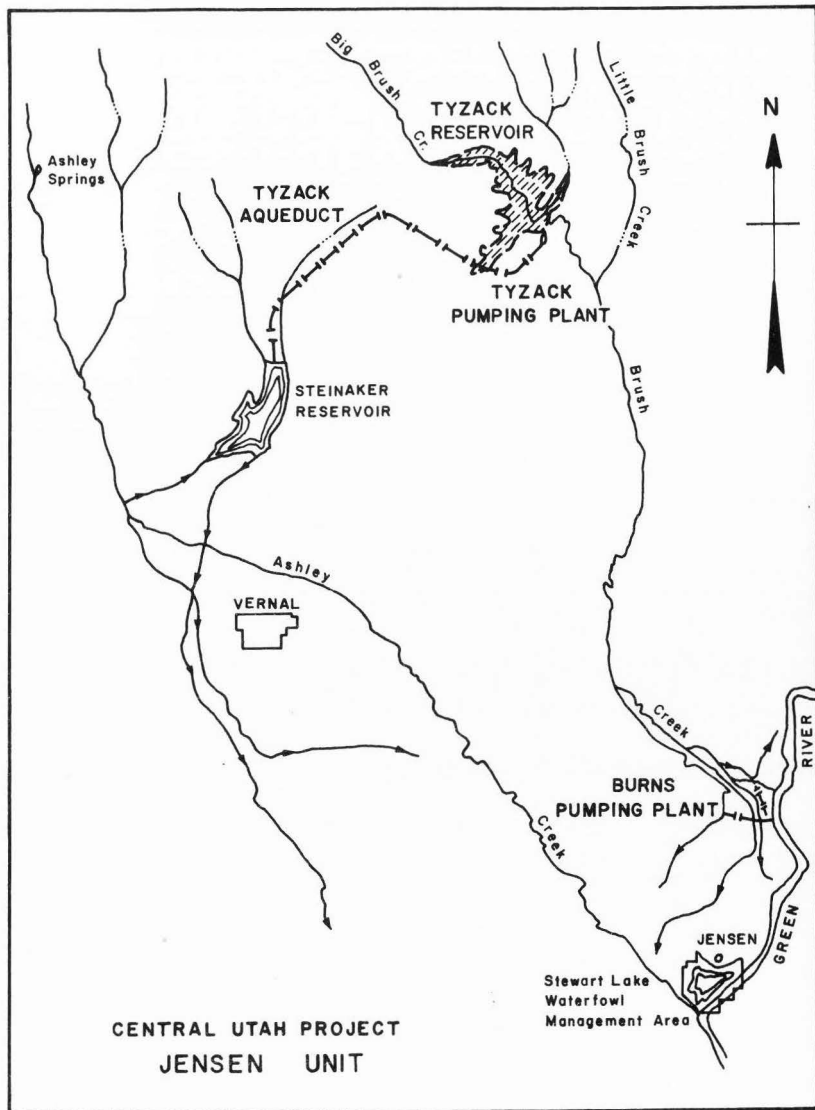


then flow by gravity to Steinaker Reservoir. The project will make the high quality water from Ashley Springs currently used by irrigators available to Vernal City in exchange for water delivered to Steinaker Reservoir for irrigation purposes.

The exact repayment schedule for the project has not been finally determined but discussions with the Bureau of Reclamation officials indicate the charges to municipal and industrial users will approach \$100 per acre foot. This amount will cover operation and maintenance and interest costs. Although few studies into the value of agricultural water in the Uintah Basin have been conducted, comparative data would indicate that the value of agriculture water would be in the neighborhood of \$10 per acre foot. Vernal City officials indicate that the transaction costs associated with obtaining agricultural water directly without replacement water will make the buying of Jensen Unit water, even at the price of \$100 per acre foot, necessary. Under terms of the agreement all water obtained from the Jensen Unit will be exchanged for water from Ashley Springs on a one for one basis. The water from the Springs will require very little treatment to meet domestic quality standards and the exchange water will still meet irrigation quality standards.

The future of the Jensen Unit was once very cloudy, but it now appears that construction on the unit will go ahead without major obstacles. Conversations with state water officials indicate that oil shale and other energy concerns provided much of the impetus behind getting the project off the ground.

In summary, it appears, on the surface at least, that there is excess water to meet additional demand due to oil shale population.



Even without the Jensen Unit, Ashley Spring would be able to provide this additional quantity. This does not necessarily mean that there will be no water taken from agriculture for municipal uses, however. Agricultural production requires land as well as water. As the population reaches out from current city boundaries, agricultural land will be taken out of production as a by-product of annexation, etc. What this section has shown is that the available water can meet the demand of oil shale population without forcing water from agriculture.

IMPACT OF OIL SHALE DEVELOPMENT ON AGRICULTURE

There has been much speculation about the impact energy development will have on existing water uses in Eastern Utah and the energy-rich West in general. Since the majority of the existing water allocations are for agricultural purposes this impact is generally thought of as a confrontation between the demand for agricultural and energy development uses. Concern has been expressed that agriculture, being unable to compete with energy as water shortages drive up prices, will sell off its water to the higher paying use. In the long run this situation is indeed possible if energy development occurs on a large scale in the years ahead. In such an eventuality, energy development will use very large quantities of water.

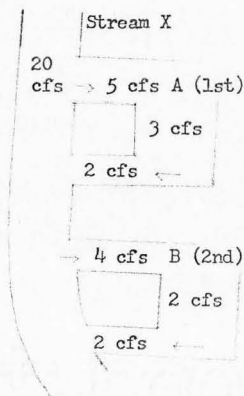
It has been shown earlier in this report, however, that the prototype oil shale operation will not seriously compete with the agricultural economy for water. The location proposed for the industrial operation is in an area which is not currently utilized for agricultural production, and the municipal growth demands can be satisfied by the existing communities. In other words, sufficient supplies are available to satisfy existing and projected demand at approximately current relative prices for water.

There are additional impediments to transfers of water from agricultural uses to energy development. Defining water rights and transferring them from agriculture to other uses involves substantial transaction costs.

It is the purpose of this section of the report to present some of the institutional constraints which make transfers of water on a purely economic basis a costly operation. Water rights transfers are often viewed as a simple exchange of property. Although water rights are legally considered as a species of real property and, therefore, transferable on the market, in reality such transfers are subject to a number of legal and institutional constraints.

All water rights on a given stream or river are closely integrated with each other. Any action (including transfer) which injures any other right is prohibited by law. Therefore, a right may be transferred only so long as it does not affect other integrated rights. In general, this may be a difficult accomplishment.

Consider a typical situation.



Assume that stream X has a total flow of 20 c.f.s. in the main water course which is completely allocated. User A has a right to divert five c.f.s. for use on his land, as illustrated in the diagram. Let us suppose that irrigation efficiency is 60 percent. Efficiency is defined as the quantity of water consumptively used as a percentage of the amount diverted. Therefore three c.f.s. are consumptively used on A's property by irrigation. The remaining two c.f.s. become return flow to the stream. User B has an inferior right to A for four c.f.s. The remaining flow of the stream is utilized among other downstream users. If an energy concern, or any other potential buyer, were to buy A's right, how much water would the buyer be entitled to?

Although B's right is inferior to A's, B's right is protected against any action which would damage his right. B's water right is dependent upon A's return flow; therefore, if A were to transfer his water right, he would only be able to sell three c.f.s. out of his total right of five c.f.s. since the other two c.f.s. are return flow upon which other rights are dependent. The same situation exists for B in that his return flow represents other downstream water rights. In other words, the usual interpretation is that only the consumptive use may be transferred.

This hypothetical situation represents an obstacle to water right transfers. The transaction costs are essentially threefold in nature: the first is the technical question of how much of a right is legally transferable. The second problem is legal in that every transfer is subject to protest and judicial review. The third problem is economic - if problems one and two are solved without cost, the value of three c.f.s. in the new use must be worth more than the

five c.f.s. diverted in the original use if transfer is to be profitable to the original user.

Another frequently mentioned aspect regarding the availability of irrigation water for energy uses is that of providing farmers with sufficient economic incentive to increase the efficiency of their irrigation practices so as to make more water available. It is well-known that flood irrigation, as practiced in the Uintah Basin, is highly inefficient. Therefore, if the farmer were to be rewarded for increasing irrigation efficiency through installation of sprinkler irrigation, for example, he would ostensibly be able to sell the saved water to energy demanders. As an example, if User A could increase his irrigation efficiency to 75 percent, he would need to divert only four c.f.s. to get consumptive use of three c.f.s. and could thus sell the one c.f.s. saved.

A more penetrating view of this example, however, reveals that the problems cited above remain. The first is the problem of return flow. No matter what efforts are taken to increase the efficiency of water use, the return flow figure may not be altered if crop requirements require a given consumptive use. This situation highlights the old adage, "One man's inefficiency is another man's water right." The Colorado River is freely utilized before it runs into the Gulf of California and increasing irrigation efficiency will not add to water availability.

There is a second legal question. Water rights are granted so that water can be put to reasonable and beneficial use. If it is shown that increased irrigation efficiency results in a surplus of water which is not being put to such a designated use, the possibility

exists that the amount of saved water would revert back to the state to be reallocated rather than being salable to other users by the original individual water right holder. This is an area of speculation, however, since there are no immediate precedents to govern this decision.

It is possible that some statutory action guaranteeing that such saved water is property of the water right holder would enable him to sell off the saved portion of his right. If so, an obvious economic incentive would exist for the farmer to increase irrigation efficiency.

Another possible deterrent to water transfers from agriculture to energy involves irrigation organizations. A major part of the irrigation in the Uintah Basin is handled through mutual irrigation companies. The members of these companies are stockholders. Such stock provides each shareholder with a given amount of irrigation water or a given percentage of the stream flow. The water right itself, however, is held in the name of the company. Most company bylaws prohibit the sale of stock for use outside of the company or for non-agricultural purposes without the unanimous consent of the stockholders. Since unanimity is often difficult to achieve, the question that arises is how might non-agricultural concerns obtain such water.

One alternative is for energy to buy out whole farms, obtain the corresponding stock, and leave the farms in agricultural production until a majority of the stock is held by the energy operation. When such a position is achieved the majority portion of the stock held by the energy developers could be severed from the other stock

held by the irrigation company. At least, the energy developers would be in a strong bargaining position. Again, there is no legal precedent to guide such action. There is, of course, the option of buying out all of the shareholders and then transferring the water to industrial uses.

A final problem in obtaining agricultural water rights concerns municipal zoning ordinances which stipulate how agricultural water is to be used once it leaves agricultural production. Such zoning laws require that once the water leaves agricultural production the control of the water reverts to the city. This situation applies only in areas under city control, however. But as cities and towns anticipate increased population and expand their boundaries, more agricultural land may find itself subject to municipal control as a means of obtaining the water.

The previous pages have not meant to imply that existing agricultural rights will never be taken for energy development. On the contrary, if large scale development should occur then water uses in agriculture may be reduced. In that case large numbers of agricultural rights will be purchased together to obtain the necessary water and avoid legal entanglements. The proposed prototype oil shale operation simply does not need enough water to warrant piecing small individual water rights together and facing the legal problems. This is particularly true when the water for the operation is available from other sources.

What then will be the impact of the proposed prototype oil shale development of lease tracts U_a and U_b on the local agricultural production. White River Oil Shale Corporation has stated categorically

that there will be no use of existing agricultural rights for the prototype plant. All the evidence that has been available seems to support this claim. Efforts have been directed toward obtaining water from sources that have not been appropriated, such as the White River. It appears that these efforts have succeeded and the proposed dam will be built. The location of the lease tracts is such that no existing agricultural production will be affected.

If anything, it appears that the proposed oil shale development might well have a positive impact on some areas of agriculture resources. Industry, in its efforts to obtain the necessary water from the state, appears willing to subsidize agriculture. For example, to proposed White River dam, although built primarily to provide water for oil shale, will in fact assist local agriculture by making it possible to irrigate some Indian land and by providing some flood control protection.

Population impacts, although significant, do not appear to be substantial enough to involve significant transfers of water from agriculture to municipal uses. This is particularly true if water for the Jensen Unit of the Central Utah Project is developed.

Lastly, the legal and institutional constraints to efforts by energy to buy up small individual water rights on a piecemeal basis seem to be quite costly.

CONCLUSION

Investigation into the physical availability of water in the oil shale area reveals that the prototype oil shale plant will have little impact on the Uintah Basin's agricultural or municipal water supplies.

Water use for the prototype plant is estimated between 13,000 acre feet per year and 26,000 acre feet per year. The difference between these estimates is the amount of water that will be used for dust control and cooling. If a new town is developed the additional municipal water for the projected population of 10,028 (see Table 2) will also have to be supplied by water near the prototype site. Based upon a consumption rate of .49 acre feet per capita (current Vernal City consumption rate) the on-site population will have to be supplied with an additional 4,914 acre feet per year. This consumption rate is very high, however. Raising the price of water discussed earlier, might lower this amount significantly. If a consumption rate of .25 acre feet per capita is assumed (Project Independence estimates) the domestic water estimates are lowered to 2,507 acre feet per year. Thus, the prototype plant and a new town of 10,028 would require a high estimate of 30,914 acre feet per year and a low estimate of 15,507 acre feet per year (see Tables 5 and 7).

A look at the water supply side reveals that the 36,000 acre feet currently proposed for segregation from the White River Dam would more than supply the high estimate of 30,914 acre feet per year (Tables 6 and 7). It should be mentioned, however, that the

proposed dam with its 118,000 acre feet of storage will supply room for some expansion of the prototype operation. (Note: At least 50,000 acre feet will be designated for Indian rights.)

At this time, it appears unlikely that a new town will be built. Therefore, the population impact discussed earlier would have to be absorbed by existing Uintah Basin communities. A look at the projected population increases in Vernal, Roosevelt and Duchesne indicates an anticipated population increase for that area of 6,011 persons. Utilizing the higher consumption rate of .49 acre feet per capita this population increase would require some 3,253 acre feet per year. The lower rate of .25 acre feet per capita projects a total of 1,661 acre feet per year. Examination of the water supply side for this same area, however, reveals that 40,195 acre feet per year may eventually be available for municipal and industrial use in the Uintah Basin (See Tables 6 and 7).

In summary, the prototype oil shale operation and the associated population increase will have no apparent impact on the Uintah Basin agricultural or municipal water supplies.

Of course, these estimates incorporate only the impact of the prototype operation of a maximum capacity of 100,000 barrels/day. If oil shale operations were to become economically feasible, water demands could expand rapidly. Other large energy developments, i.e., coal gasification and liquefaction, could also expand quickly and demand huge quantities of water. The question then arises as to the capacities of existing water supplies to support a large scale population increase and further industrial development.

Based on the low consumption rate of .25 acre feet per capita the 40,195 acre feet available to the Uintah Basin would support a population of over 150,000. The limiting factor, as far as water for oil shale is concerned, appears to be the industrial water from the White River Dam. If an additional 26,000 acre feet per year is required for each 100,000 barrel/day operation, the White River project would only be able to supply sufficient water for a 200,000 barrel/day industry before impinging upon Indian claims, providing additional water supplies cannot be found.

Examination of the institutional and legal framework of the appropriative doctrine in general and of Utah water law specifically reveals that the basic orientation of such laws is protective of existing water rights. They are protected from harm from other potential water users even though a given water use may be more beneficial in an economic sense.

Although water rights are considered real property statutorily and are transferable on the open market, in reality transfers are restricted by current laws unless the criterion of non-injury to other water rights is met. The fundamental underpinning of the appropriative doctrine is preservation of the existing right at the expense of later rights. The primary goal of the institutional apparatus of the state (the water law and the office of the State Engineer) is the maintenance of an "equitable" distribution of this public resource.

Unfortunately, this desire for equity often conflicts with efforts to maximize efficiency in water use. It has been shown in this study that although the value productivity of water used

in energy production is significantly higher than that of water utilized in agriculture, efforts by energy to bid water away from agriculture are often severely restricted by current legal and institutional restraints. Water may be kept in a less productive use by the high transaction costs associated with transferring water rights. Transfers must be preceded by public hearings and the burden of proof of non-injury to other right holders is on the parties wishing the transfer. This often requires technical information that is expensive to acquire. Because of these transaction costs, oil shale developers may well find it easier and less costly to obtain the needed water from the state's supply of unallocated water, at least for the prototype development.

It has not been the intention of this study to imply that the preservation of existing agricultural rights is of greater importance than obtaining water for oil shale development. Rather, the orientation has been to present the current legal and institutional impediments to water right transfers. Obviously, these restrictions are geared toward preservation of already granted rights. A question might arise, however, concerning the impact on agriculture and other rights if such restrictions did not exist or if the institutional structure were modified to accommodate easier transfer.

It is generally accepted that if agriculture were stripped of the protection it now enjoys that it would not be able to compete economically with municipal and industrial demands. This is particularly true with respect to energy operations such as oil shale where the demand price for water is quite high and the demand curve for water is likely highly inelastic. Expenditures for water

constitute a very small proportion of the total costs of producing oil from shale and no good substitutes are available for water in such uses as soil compaction and revegetation. This is tantamount to arguing that the demand curve for water can be expected to be highly inelastic. Thus, no one seems to argue that oil shale producers could not bid water away from agricultural users. In an economic welfare context, however, would this necessarily imply a reduction in social welfare?

If transaction costs were zero, if transfers were made voluntarily, and if no external costs and benefits were imposed on others, the free market solution to the water allocation problem would in reality conduce to maximum economic welfare. Water would move to its highest value and economic efficiency criteria would be satisfied. But how about equity? It must be assumed that if a farmer is receiving sufficient incentive to part with his agricultural water in the market in a voluntary transaction, that he prefers the transfer to maintaining his right. Likewise, the energy developer would be receiving the use of a resource for which he had compensated the farmer. Neither party can be considered to be worse off and, therefore, the Pareto conditions for an optimum are satisfied. This situation reflects the basic free market belief that with the exception of resource transactions involving externalities the market allocates resources on the most efficient and equitable basis.⁷⁴

There would be some secondary economic effects associated with any decline in agricultural production in the proposed oil shale area,

⁷⁴E. J. Mishan, Welfare Economics: An Assessment, North Holland Publishing Company, 1969.

however. Support industries such as equipment retailers, fertilizer suppliers, transport and marketing firms, would appear to be worse off if agriculture declined. The area's economic position in general, however, may not be negatively affected since presumably oil shale development would bring with it jobs, increased commerce and incomes, and more tax revenue. Thus, other secondary businesses would gain and these gains would appear to more than offset the losses to the auxiliary agricultural industries.

The conclusion of this study is that current water laws and institutions will be an important factor in determining how and if water will be available for oil shale development. It has been publicly stated by Utah's prototype oil shale developers that the prototype operation will not attempt to utilize existing agricultural water rights or sources for the initial oil shale operation. This position reflects the belief that the transaction costs associated with obtaining this water are at the moment too high when compared with the possibility of obtaining water from other sources. On the basis of this information, it appears that oil shale development will not have any substantial impact on the area's agriculture in a direct sense. There is the possibility that population increases associated with oil shale will require the affected communities to obtain the additional domestic water from agricultural sources. Proper management coupled with efforts to define ownership of the area's water sources should eliminate many of the problems facing communities in obtaining the needed municipal water. Lastly, long delayed projects like the Jensen Unit of the Central Utah Project could eliminate most of the problems facing industry, municipalities, and agriculture in finding adequate water.

Although there appears to be sufficient water to meet agriculture and energy demands in the Uintah Basin at the moment, the potential for conflict underlies a fundamental inadequacy of current water legislation, i.e., the inability of current water controls to adapt to synamic change in water demand. Utah water law declares that all water in the state is to be considered the property of the public. This statement does not vest title to the water in the state, but does stipulate that water is community property available only upon compliance with the law. Water, however, is a fugitive resource which is only of non-recreational value when it is taken from its source and is used. The role of institutional controls is ostensibly to manipulate the system to obtain the greatest public benefit. The system becomes onerous, however, when laws and organizations created to be the manipulators prevent economically efficient transfers.

Historically two methods have been employed to ration resources. One is legislative and administrative control. This is the method most commonly utilized in water allocation in Utah today. As a result, agricultural water has been heavily subsidized at the expense of municipal and industrial uses. This has been done by statute and administrative procedures influencing how water would be priced, assigned to land, and development costs distributed. The other method is market allocation by price. What this study has pointed out is that current controls exist to the point that only rarely is there a free market for water.⁷⁵

⁷⁵Gardner, B. Delworth and Fullerton, Herbert H., Rising Water Values that Result from Increased Mobility, Bulletin 476, Utah State University, Logan, Utah, October 1968.

Hopefully as the fact is faced that water will not be available for all potential competing uses, water institutions can be modified to permit this scarce resource to be allocated to uses and users of greatest productivity and still protect the equity positions held by current right holders.

Table 5. Water requirement demand summary for the prototype oil shale development at various population assumptions.

| | High Estimate (a.f./yr) | Low Estimate (a.f./yr) |
|--|----------------------------|---------------------------|
| 1. Prototype Oil Shale Plant (Max capacity 100,000 barrels/day) | 26,000 | 13,000 |
| <u>Population:</u> | | |
| 2. Total Estimated Population Increase (including Rangely, Colorado) 12,535 | 6,142 ^{*a} | 3,134 ^{*b} |
| 3. On-site Population (assumes new town) 10,028 | 4,914 | 2,507 |
| 4. Vernal-Ashley Valley (assumes no new town) 3,958 | 1,940 | 990 |
| 5. Roosevelt (no new town) 1,574 | 771 | 394 |
| 6. Duchesne (no new town) 479 | 235 | 120 |
| 7. Other Uintah Basin (no new town) 627 | 307 | 157 |
| <u>Totals:</u> | | |
| Plant totals and total population water estimates (1,2) | 32,142 | 16,134 |
| Total estimated Utah (Uintah Basin) water requirement (assumes no new town) (4,5,6,7) | 3,253 | 1,661 |
| Plant total and total Uintah Basin pop. water estimate (assumes no new town) (1,4,5,6,7) | 29,253 | 14,661 |

^{*a}Assumes .49 a.f. per capita^{*b}Assumes .25 a.f. per capita

Table 6. Water supply summary

| | |
|---|--|
| Prototype Plant Operation (Max capacity 100,000 barrels/day) | Proposed White River Dam Segregation of 36,000 a.f. from total of 118,000 a.f. storage |
| <u>Vernal-Ashley Valley</u> (clear and unrestricted rights) | 6,711 a.f. |
| Rights were title may be under dispute | 8,153 a.f. |
| Future sources - Jensen Unit | <u>18,000 a.f.</u> |
| Subtotal: | 32,863 a.f. |
| <u>Roosevelt</u> Uriah Heap Springs, Hancock Cove Well, Campbell Well | 5,718 a.f. |
| <u>Duchesne</u> Murray Springs Area Wells | <u>1,614 a.f.</u> |
| Uintah Basin sources | 40,195 a.f. |
| TOTAL: White River Dam and Uintah Basin sources | 76,195 a.f. |

Table 7. Summary comparison of total plant and population water estimates and total Uintah Basin and White River Dam water supply sources.

| Requirements/Needs | | | Supply |
|--|--------------------------|-------------------------|--|
| | <u>High</u> (a.f./yr) | <u>Low</u> (a.f./yr) | |
| 1. Total plant water requirements and total population water estimates | 32,142 | 16,134 | Uintah Basin sources - 40,195 a.f. |
| 2. Total plant water requirements and new town water estimates | 30,914 | 15,507 | |
| 3. Total plant water requirements and total estimated Uintah Basin population water estimates (assume no new town) | 29,253 | 14,661 | Uintah Basin sources - and White River Dam 76,195 a.f. |

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